ESTIMATING THE EFFECTS OF RADIO FREQUENCY IDENTIFICATION (RFID) TAGGING TECHNOLOGIES ON THE ARMY'S WAR-TIME LOGISTICS NETWORK

Graduate Research Project

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Abstract

Some civilian business practices, such as radio frequency identification (RFID) tags, were used for the first time by the Army in a major conflict during Operation Iraqi Freedom (OIF). RFID tags were attached to every container and pallet in all sustainment shipments entering and exiting the area of operations (AOR). Although RFID tagging was somewhat successful during OIF, the logistics network still suffered significant problems, to include lack of asset visibility and ineffective theater distribution. Implementing business practices on the battlefield seems like an easy answer to these problems, but the implementation of RFID tags may or may not easily transition to a military of combat environment.

The purpose of this research was to discover if the business practice of using RFID tags to track equipment and supplies could be effectively used in a war-time environment by the Army's logistics network. Using grounded theory and content analysis methodologies, this research sought to understand the similarities and differences between how RFID tags are being used by civilian industry and the Army, and if RFID tags can apply to a war-time scenario. Data collection included interviewing industry subject matter experts regarding RFID tag use and implementation, and an extensive analysis of OIF lessons learned. Data was tabulated and compared, and similarities and differences were identified. The research then highlighted how RFID tags could improve asset visibility and theater distribution during war, and the limitations associated with transitioning RFID tags from a civilian supply chain to the Army's war-time logistics network.

Acknowledgments

I remember the exact moment in LOGM 627, Supply Chain Management, when Lt Col Swartz asked the class if we thought RFID tags would have solved Operation Iraqi Freedom's in-theater asset visibility problems. After a pause, he added "And boy, that would sure make a good GRP topic!"

A sincere thank you to Lt Col Swartz for first recommending this topic, and then serving as my advisor as I stumbled through an unbelievable amount of data to make this a reality.

Many thanks to my husband for his encouragement and listening ear during my late-night, sleep-deprived phone calls…ten months apart initially seemed like a long time, but it flew by!

Finally, I can never thank my fellow GLM IDE classmates enough. This GRP and my success at AFIT would not have happened without their support and friendship.

Kristina M. O'Brien

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ESTIMATING THE EFFECTS OF RADIO FREQUENCY IDENTIFICATION (RFID) TAGGING TECHNOLOGIES ON THE ARMY'S WAR-TIME LOGISTICS NETWORK

I. Introduction

Background

The Army's Surface Deployment and Distribution Command (SDDC) is currently undergoing a transformation, to include a new model for military logistics. They are working closely with the Department of Defense (DoD) to integrate logistics networks and to improve logistics operations, and they have studied civilian logistics practices and strategies. As a result, SDDC is integrating some civilian processes into its operations. According to Major General Ann E. Dunwoody, SDDC's commander, "the commercial industry is our benchmark" and "we try to take the best of industry practices to streamline our process" (Harps, 2003).

Some civilian business practices, such as the utilization of radio frequency identification (RFID) tags and just-in-time (JIT) inventory, were utilized for the first time by the Army in a major conflict during Operation Iraqi Freedom (OIF). RFID tags were attached to every container and pallet in every sustainment shipment entering and exiting the area of operations (AOR). Vendors applied the tags prior to initial shipment, or tags were added to pallets, bins, or containers at the aerial ports or at distribution centers. From January to June 2003, over 25,000 containers were tagged (Stewart, 2003). Although RFID tagging and some other Automated Identification Technology (AIT) applications (which will be discussed in depth in the Literature Review) were somewhat successful during OIF, the logistics network still suffered many significant problems.

On 2 October 2003, the Department of Defense established a policy for the use of RFID within the DOD. The policy requires the DOD to develop business rules based on results of initial RFID projects, and to issue a final policy of usage in July 2004. In addition, the policy requires suppliers to place passive RFID tags on the lowest part, case, or pallet possible by January 2005 (Wynne, 2003). An RFID-enabled DOD supply chain "will provide a key enabler to the asset visibility support needed by our warfighters" (Wynne, 2004). To prepare for the implementation, the DOD will partner with industry and leverage commercial sector initiatives (Estevez, 2003).

Similar to the DoD's initiative, Wal-Mart Stores, Inc., announced in June 2003 it will require its top 100 suppliers to attach RFID tags on all shipping crates and pallets destined for Wal-Mart by January 2005 (Brewin and Vijayan, 2003). Wal-Mart is the world's largest retailer, and has extensive influence over industry practices. The DoD is even larger, and has a supply chain unmatched in diversity by any commercial industry (Gilligan, 2004). The DoD and Wal-Mart will certainly communicate throughout implementation, but it is important to note that the retailers and DoD will have different objectives for RFID. William Phillips, head of IBM's defense industry consulting business notes that "DoD requirements are similar to industry's at a high level, but as you drill down, DoD's focus in on readiness…its supply chain is more widely distributed and fluid" (Jackson, 2004). Despite the adoption of RFID by commercial industry, can the technology effectively transition to a wartime environment?

Problem Statement

Although combat operations during Operation Iraqi Freedom were extremely successful, logistics support problems existed throughout the area of operations.

Identified as “the most challenging operation conducted on the battlefield” in the 3rd Infantry Division’s After Action Report (2003), as well as in others, the logistics distribution and management system did not meet all the requirements of the deployed force. Problems included lack of asset visibility, ineffective theater distribution and use of just-in-time practices, and supply chain security issues (USGAO, 2003).

Although implementing business practices on the battlefield seems like an easy answer to the lack of asset visibility and ineffective theater distribution, the implementation of civilian business practices may or may not easily transition to a military or combat environment. This research will provide background on the usage of AIT in OIF, then describe in detail how RFID, a subset of AIT, may, or may not, transition to the battlefield.

Research Question

The focus of this research is to answer the question: How can the business practice of utilizing radio frequency identification (RFID) tags to track equipment and supplies be effectively utilized in a war-time environment by the Army’s logistics network?

Investigative Questions

To answer the research question, this research will address the following investigative questions.

1. How is RFID technology being used by civilian companies to run their supply distribution network?

2. What processes are employed by civilian companies to successfully implement and use RFID tags to help achieve asset visibility in situations similar to the Army?

3. What logistical problems did the Army encounter in their overall supply distribution network in Iraq during the combat phase of OIF?

4. How did the Army's logistics network employ AIT during the combat phase of OIF?

5. What problems did the Army's logistics network encounter with the different AIT technologies during the combat phase of OIF?

6. What similarities and differences exist between the civilian companies' and the Army's implementation and usage of RFID tags?

Research Objective

The primary objective of this research is to determine similarities and differences between how industry and the Army are implementing and using RFID in their supply chains or logistics networks. Once these similarities and differences are identified, the research will highlight how these similarities and differences may, or may not, lead to success when utilized during war-time by the Army's logistics network.

Since RFID is rapidly evolving as an enhancement to the supply chain, this research, by identifying differences between the Army and industry, may also identify additional ways RFID technology can be implemented and used in the future.

Scope and Limitations of Research

This research assumes both similarities and differences exist in the usage of RFID by industry and the Army in their supply chains or logistics networks, and will identify these similarities and differences in an effort to pinpoint where the business practices overlap.

The research will use the Army's logistics network in OIF as a baseline for comparison between industry and the Army. Data addressing OIF lessons-learned will be

primarily collected from after action reports, and data outlining AIT and RFID usage will be from reports, articles, and command-level briefings. All after action data used in the research will be unclassified.

Data collected for the literature review and to address several of the investigative questions will be from current literature, as well as from structured interviews. Sources for the interviews include senior mangers or information technologists responsible for RFID usage or implementation in industry. One purpose of the literature review is to identify civilian corporations using and implementing RFID with a supply chain as similar as possible to the Army's. RFID technology is currently evolving as a business practice. As a result, literature utilized for this research will be primarily from news sources, periodicals, reports, and briefings.

Methodology

This research will use a grounded theory methodology to address the investigative and research questions. Strauss and Corbin define the grounded theory approach as a qualitative research method that uses a systematic set of procedures to develop and inductively derive grounded theory about a phenomenon (1990). Although grounded theory will be the primary methodology, content analysis will also be used. Leedy and Ormrod define content analysis as a detailed and systematic examination of the contents of a particular body of material for the purpose of identifying patterns, themes, or biases (2001). Analysis is usually conducted on forms of human communications, including books, newspapers, and videotapes.

Data regarding the implementation and usage of RFID by both industry and the DoD, as well as lessons-learned on AIT usage by the Army during OIF, will be collected,

coded, and analyzed. The data will then be compared to identify similarities and differences between industry and DoD usage of RFID, and to develop theory regarding the potential effectiveness of RFID in the Army's logistics network during contingencies. The data will be presented in tabular and graphical form to depict the similarities, differences, and frequencies of findings.

Summary

This chapter discussed the background and problem, described the research and investigate questions, and provided an overview of the scope and methodology of the research. The remaining four chapters will include the Literature Review, the Methodology, the Findings and Analysis, and Conclusions. The literature review will begin by providing an overview of AIT, and will then focus specifically on current RFID policy, practices, usage, and initiatives. The review will then address the logistical problems encountered by the Army in their overall supply distribution network in Iraq during the combat phase of OIF, and will then be scoped to identify how the Army's logistics network employed AIT, and what problems were encountered with the technologies, during the combat phase of OIF. The literature review will also provide research on how civilian companies are currently employing RFID in their logistics networks.

Chapter Three will outline the research's methodologies, grounded theory and content analysis, and will explain how the data will be collected and analyzed.

Chapter Four will address and answer, with supporting data, each of the six investigative questions. Data analysis, theories, and conclusions, based on the analysis, will also be presented.

Chapter Five highlights limitations encountered during research, and will also provide recommendations for future research. A final conclusion will be included within this chapter.

II. Literature Review

Introduction

To develop theory regarding the potential effectiveness of using RFID tags to track equipment and supplies by the Army's logistics network during wartime, data in associated topics must be collected, coded, and analyzed. This literature review is the initial step in the theory-generation process, and will provide a detailed review of topics relating to this study.

This review will first outline total asset visibility (TAV) and its subsets, automated information systems (AIS) and AIT, to include pertinent Army AIT. The review will then provide background on how RFID is being used by civilian companies to run their supply distribution networks. The review will then switch focus from TAV and AIT to the use of AIT during Operation Iraqi Freedom by the Army in their supply distribution network, and the problems encountered with these technologies during OIF.

Total Asset Visibility (TAV)

Introduction.

The DoD shipped over 6.5 million tons of cargo to Saudi Arabia before and during Operation Desert Storm, and in the rush to deploy, many of the containers were poorly marked, if marked at all. Approximately 30,000 of the 40,000 containers shipped had to be opened and searched to identify the contents—a time consuming and inefficient process (Kennedy, 2003). "Iron mountains" of equipment and containers piled up, and personnel had to dig through the stock piles to locate required supplies. In an effort to improve the DoD logistics system post-Desert Storm, several TAV programs were initiated, and the DoD began using AIT extensively to improve TAV.

This section of the literature review will provide background on the different DoD TAV initiatives, programs, and systems currently in use, with an emphasis on Army systems. It will also outline the different AIT initiatives and technologies being used by the DoD, to include RFID.

Department of Defense TAV Initiatives.

The Joint Total Asset Visibility (JTAV) Program Management Plan defines total asset visibility as the "capability for users to view information on the identity and status of DoD material assets and, in some cases, complete a business transaction using the information" (JTAV PMP, 2001). Total Asset Visibility is an overarching concept which includes three main areas: in-storage, in-process, and in-transit (JTAV PMP, 2001).

In-storage TAV includes wholesale and retail assets held as inventory; Warehouse Management Systems enable automated tracking in this area. In-process TAV includes assets in maintenance or procurement, and Order Management Systems enable the automated tracking of inventory during this phase. In-transit assets are assets that have been shipped to a destination, and these assets can be tracked using transportation management systems.

In-transit visibility (ITV) is the subset of TAV that focuses on tracking the identity, status, and location of cargo and passengers from origin to destination during peacetime, contingencies, and war (Department of Defense, 1995). Critical functions of Joint ITV include ITV for all classes of supply; in-transit status of unit moves, sustainment supplies, equipment, and personnel; identification of cargo and distribution assets underway in the transportation process; and two-way communication on specified distribution platforms (JP 4-01.8, 2000).

Joint Total Asset Visibility.

In response to the lack of asset visibility in Desert Shield and Desert Storm, the Defense Total Asset Visibility Implementation Plan, published in 1995, outlined the requirements to provide TAV for DoD, and addressed four areas: requisition tracking, visibility of assets in-storage or in-process, visibility of assets in-transit, and logistics management for the theater of operations. The plan designated the Joint Total Asset Availability Program responsible for demonstrating new technologies and testing their associated solutions in an effort to provide Joint Total Asset Visibility (JTAV) (GAO D-2002-057). JTAV, basically a subset of TAV, is the capability to provide users with timely and accurate information on the location, movement, status, and identity of units, personnel, equipment, and supplies (JTAV PMP, 2001) for the Combatant Commander and his warfighters.

The Deputy Under Secretary of Defense (Logistics) (DUSD(L)) established the Joint Total Asset Visibility (JTAV) Office in April 1995 with the goal of providing the Combatant Commanders and Joint Task Force Commanders a view of theater assets (JTAV PMP, 2001). The JTAV office focuses on providing joint total asset visibility in-storage, in-process, in-transit, as well as in-theater, to maximize the warfighter's capabilities. Aside from providing more efficient and effective logistics system capabilities, JTAV strives to provide material identification from systems using Automated Identification Technology (AIT) to improve the warfighter's ability to identify in-transit or in-storage assets (JTAV PMP, 2001).

The JTAV office monitors TAV system implementation by the Combatant Commands, as well as the individual Services. Of special interest is the United States

Transportation Commands' Global Transportation Network (GTN), the Defense Logistics Agency's AIT efforts (AIT oversight was transferred from the DUSD(L) to DLA in June 1998), and the Army, Navy, Air Force, and Marine Corps' individual TAV efforts (GAO/NSIAD-99-40).

Joint Vision 2020.

Joint Vision 2020 identifies Focused Logistics as the ability to provide the joint force the right personnel, equipment and supplies in the right place, at the right time, and in the right quantity, across the full range of military operations (JV 2020). The goal is to link logistics functions and units through information systems that integrate real-time total asset visibility, with the ultimate goal of providing a link between operations and logistics which results in time-definite delivery of assets to the warfighter. A goal of the Focused Logistics Transformation Plan is to implement fixed and deployable automated identification technologies and information systems that provide accurate, actionable total asset visibility no later than Fiscal Year 2004 (JV 2020).

Automated Information Systems (AIS).

Introduction.

Automated Information Systems interface with commercial transportation information systems, and receive and pass personnel, unit, and cargo movement data and other transportation information to the appropriate organizations throughout the defense transportation system (FM 55-80, 1997). An alternate definition identifies AIS as an automated command and control system that implements the exchange of information among the Combatant Commanders, the Services, and the functional component commands, with a goal of providing battlefield knowledge (JP 4-01.8, 2000).

Automated Identification Technology can them be defined as a suite of equipment and storage media that operates within the bounds of AIS. AIT, to be discussed within the next section, is a valuable component or peripheral system within AIS (FM 55-80).

This sub-section of the literature review will provide background on the Army's Automated Information Systems, providing a framework for future discussion and review on how these systems, and associated AIT, were used during Operation Iraqi Freedom.

Global Transportation Network.

The Global Transportation Network (GTN) is the DoD's designated information system responsible for visibility of assets in-transit from origin to destination, to include all military and government shipments. GTN collects and integrates data, and has the capability to identify and track unit and non-unit cargo, passengers, patients, forces, and military and commercial airlift, sealift, and surface forces. GTN is not merely a database, but a network of integrated systems that provide the Unified Commanders, the Services, and other DoD customers visibility of assets moving through the transportation system (GAO/NSIAD-99-40).

Standard Army Management Information Systems.

Standard Army Management Information Systems (STAMIS) are used for the detailed, day-to-day processing of timely and accurate information supporting Combat Service Support (CSS). STAMIS rely on AIT to provide much of the detailed information required for effective theater distribution (FM 100-10-1).

Department of the Army Movement Management System-Revised (DAMMS-R).

DAMMS-R is the Army's theater cargo movement and mode asset management system that provides timely and accurate information to movement managers, highway

regulators, and mode operators within the area of operations. The system provides detailed shipment planning information, to include destination information and cargo on hand, and it can develop pick-up/delivery schedules to assist in maximizing transportation assets (FM 100-10-1).

Standard Army Retail Supply System (SARSS).

Several variations of the SARSS exist, with a focus on different levels of support and administration.

SARSS-1: The automated supply system used at all echelons to accomplish the receipt, storage, and issue mission. SARSS-1 interfaces with the Unit Level Logistics System.

SARSS-2A: Used at the division, brigade, or cavalry level, it provides item managers the capability to establish stock levels and to control lateral issues between agencies. SARSS-2AC/B provides the same management capabilities at the corps/theater level (FM 100-10-1).

Standard Army Ammunition Supply System-Modernized (SAAS-MOD).

SAAS-MOD manages all conventional ammunition, guided missile large rockets and their components, and packaging material by integrating all retail munitions supply functions and processes. SAAS-MOD provides assets to tactical commanders during wartime conditions, utilizing desk-top computers and AIT. SAAS-MOD interfaces with DAMMS-R and the Unit Level Logistics System (FM 100-10-1).

Unit Level Logistics System (ULLS).

ULLS is used to requisition supplies, dispatch vehicles, manage receipts, and complete logistics planning activities. Depending on the unit mission (maintenance or

aviation, or brigade staff), different variations of ULLS are used. ULLS has automated interfaces with the Standard Army Retail Supply System (SARSS) and the Standard Army Ammunition System (SAAS) (FM 100-10-1).

Movement Tracking System (MTS).

The Movement Tracking System supports distribution management throughout the AOR, and provides unprecedented movements tracking, control, and management capability. It provides near real-time information on the status and location of logistics transport vehicles and some combat support and combat service support vehicles through various technologies, to include Global Positioning System (GPS), AIT, and non-line of sight communication. AIT documents departure and arrival times within the theater, enabling asset visibility (FM 100-10-1).

MTS provides the Army theater distribution system the capability to track vehicle locations, communicate with vehicle drivers, provide real-time in-transit visibility of movement, and redirect vehicle movement based on changing battlefield requirements (FM 100-10-1).

Summary of AIS Technologies.

In summary, AIS can be defined as systems that interface with commercial transportation information systems, and receive and pass personnel, unit, and cargo movement data to the appropriate organizations throughout the defense transportation system. This section identified and described the systems that operate within the Army's Standard Army Management Information Systems, which then passes vital information to GTN. These systems rely on AIT to upload much of their data, and they are capable of passing the data laterally, as well as vertically.

Since a baseline for understanding Army AIS has been established, the literature review will now focus on AIT and its applications.

Automated Identification Technology (AIT).

Introduction.

Automated identification technology is a suite of technologies enabling the automatic capture of source data, thereby enhancing the ability to identify, track, document, and control material and maintenance processes; deploying and redeploying forces; equipment; personnel; and sustainment cargo (Stewart, 2004). AIT uses a variety of different storage media to capture and store asset data, and can provide the data electronically to logistics automated information systems to better achieve TAV while streamlining business processes and warfighting capabilities (DoD IPLAIT, 2000). AIT minimizes human intervention in the collection and transfer of data, therefore increasing productivity and reducing the possibility of error.

The Deputy Undersecretary of Defense (Logistics) established the DoD Logistics AIT Task Force in January 1997 to develop a logistics AIT Concept of Operations (CONOPS). The CONOPS, published in November 1997, emphasized the development of interoperable AIT media and infrastructure to support asset visibility and logistics operations (DoD IPLAIT, March 2000). According to the DoD Implementation Plan for Logistics AIT Technology, "the DoD seeks to integrate AIT into logistics business processes to facilitate the collection of initial source data, reduce processing times, improve accuracy, and enhance asset visibility. AIT devices will be applied to support business processes as well as the AIT requirements of all users in the DoD logistics chain" (DoD IPLAIT, March 2000).

The Defense Material Management Regulation, DoD 4140.1R, was updated in 1993 to reflect the growing importance of AIT within the DoD. The regulation required DoD components to incorporate and maximize the use of machine-readable AIT devices within collection devises, and to consider AIT as the preferred system for input and data collection (Department of Defense, 1993). It is interesting to note that DoD 4140.1R was published several years prior to the AIT CONOPS and the DoD Implementation Plan for Logistics AIT Technology. This highlights how important the AIT concept became in the aftermath of Desert Storm.

This sub-section of the literature review will provide background on AIT, which includes a variety of different media and supporting technologies that link with AIS to provide TAV. Descriptions and images of AIT currently being utilized by the DoD are outlined below.

Bar Codes.

A bar code is an array of parallel, narrow, rectangular bars and spaces that represent a group of characters. A reader scans the bar code, decodes it, and transfers the data to an AIS. There are two types of bar codes in use in the DOD: linear and two dimensional (DoD IPLAIT, 2000).

Linear Bar Codes.

A linear bar code represents a limited group of characters, usually about 20, and is used to represent key data elements such as a national stock number, document number, or transportation control number. Linear bar codes can be used to provide document control information for individual items and shipments, and the Army has used them for material release orders and transportation control and movement documents (TCMD).

Bar codes are often used in a supply support activity to identify items for inventory data, and have an error rate of about 1 to 1.34 million (DoD IPLAIT, 2000; FM 100-10-1; Stewart, 2004).

Figure 1. Linear Bar Code

Two Dimensional (2D) Bar Codes.

A 2D bar code holds approximately 1,850 characters, and the error rate is 1 in 7.1 million reads. In addition, the 2D bar code is readable even if damaged. A 2D bar code can be used as an automated key to preposition data in an AIS, and it can also be used to transfer data to process an item. An example of a 2D bar code is a military shipping label, which can be used to populate an AIS with all key information associated with a package. In addition, 2D bar codes can be used as low-cost data carriers for large amounts of data associated with a container or multipack, as the 2D bar code can contain full transportation control and movement documents (TCMD), stock numbers, and document number level of detail (DOD IPLAIT, 2000; FM 100-10-2, 1999; Stewart, 2004).

Figure 2. Two Dimensional Bar Code

Contact Memory Buttons (CMB).

The CMB, about the size of a watch battery, can hold up to 64 kilobytes of information and can tolerate harsh environmental conditions. Portable button readers and

serial links that provide an interface with a computer are used to read buttons, but they can not be read remotely. Although buttons can tolerate up to 1 million read-write cycles, they cost up to 600 times more than a bar code. Buttons have been used by the Navy to maintain maintenance records on aviation components and to calibrate data on electronic components (DOD IPLAIT, 2000; FM 100-10-2, 1999; Stewart, 2004).

Figure 3. Contact Memory Button

Satellite Tracking Systems (STS).

Although not considered AIT, STS can be combined with AIT to provide a near-real time tracking capability. STS can be used to track the location of convoys, vehicles, trailers and containers by equipping the vehicle with a transceiver unit, which relays data to a satellite, transfers the data to a earth station, and then to a network control, and ultimately, to a satellite tracking operations center (DOD IPLAIT, 2000; Stewart, 2004).

Figure 4. Satellite Tracking System

Optical Memory Card (OMC).

Operating under the same reflective technology as a compact disk (CD) or CD-ROM (read-only memory), data is etched on an OMC with a high-intensity laser and read using a low-power light beam. About the size of a credit card, OMCs, which utilize WORM (write once, ready many times) technology, can store up to 2.4 megabytes of data. Since data is stored in a sequential manner, OMCs are useful for creating a permanent audit trail (DOD IPLAIT, 2000; Stewart, 2004).

Figure 5. Optimal Memory Card

S*mart Card/Common Access Card (CAC).*

About the size of a credit card, smart cards include an electronic chip that can store from 8 to 32 kilobytes of data. The card may also include additional AIT, such as bar codes and magnetic strips. Smart cards are used for personnel functions, such as manifesting, and are being implemented throughout the DOD as the standard military identification card (DOD IPLAIT, 2000; FM 100-10-2, 1999; Stewart, 2004).

Figure 6. Smart Card

Radio Frequency Identification (RFID).

Radio Frequency Identification is an automatic data capture technology that uses radio-frequency waves to transfer data between a reader and an item to identify, categorize, and track information. The technology can be passive or active, and capabilities vary depending on the type of tag used (Harmon, 2003).

RFID, although in use for over a decade, has recently become an emerging technology for tracking inventory and cargo within logistics networks. RFID and its capabilities will be discussed in detail in the next section of the Literature Review.

Summary of AIT Technologies.

In summary, AIT is a suite of technologies, including bar codes, smart cards, and RFID, that enable the automatic capture of source data, thereby enhancing the ability to identify, track, document, and control material, maintenance processes, deploying and redeploying forces, equipment, personnel, and sustainment cargo. This section identified and described AIT currently in use by the DoD, and these technologies, particularly RFID, will be important throughout this research effort.

Summary of Total Asset Visibility.

As defined earlier, TAV is the capability for users to view information on the identity and status of DoD material assets and, in some cases, complete a business transaction using the information. Total Asset Visibility is an overarching concept which emphasizes visibility of items in-storage, in-process, and in-transit. Joint Total Asset Visibility adds a fourth component, in-theater visibility, or logistics management in

theater. This research, and the associated literature reviewed, focuses primarily on in-theater visibility.

The literature reviewed provided a summary of the DoD's TAV initiatives, and summarized the importance of TAV in the joint arena. It also provided background on AIS, and described the various AIS systems utilized by the Army to maintain TAV during wartime. Finally, the literature reviewed the different AIT technologies that read data and transmit it to the applicable AIS. The AIS may share the data with other systems, as well as forward it to ensure JTAV.

The final important take-away from this section of the literature review is the interconnectivity of the systems: AIT feeds AIS, and the AIS laterally and vertically feeds other AIS. When multiple AIS are combined, the systems provide ITV and TAV. Figure 7 depicts TAV from an Army viewpoint; in-theater systems discussed in the literature review are highlighted.

Radio Frequency Identification (RFID)

Introduction.

The Auto-ID Center, which is a partnership between academia, to include the Massachusetts Institute of Technology, the University of Cambridge in England, and the University of Adelaide in Australia, and over 50 global organizations, including Wal-Mart, Proctor and Gamble, Gillette, and the Department of Defense, has a vision of placing low-cost RFID tags on every manufactured item to enable worldwide tracking.

To reach this vision, the Auto-ID Center is designing, building, testing, and deploying a universal, open standard for identifying products using RFID tags (Auto-ID).

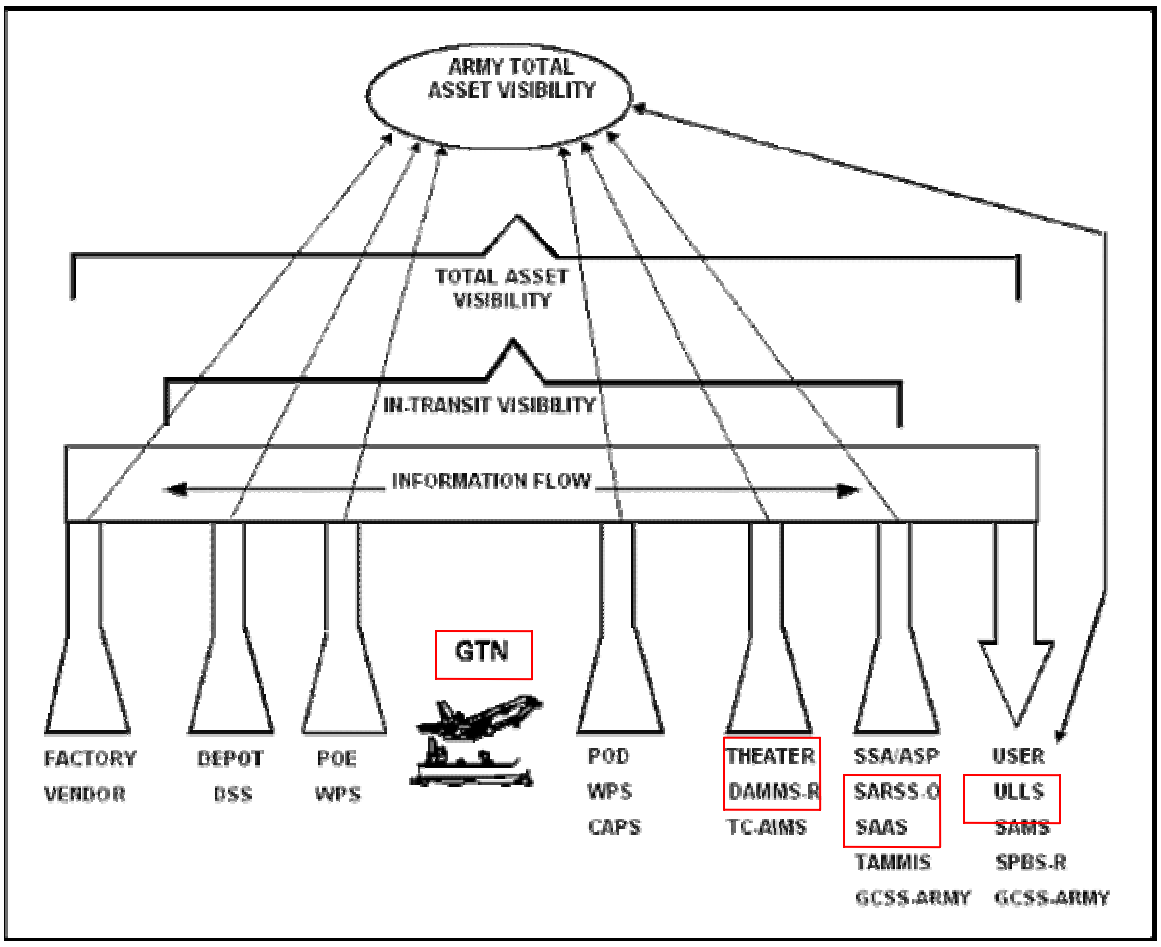


Figure 7. Army TAV (FM 100-10-1, 1999)

Although reams of literature are available on RFID, the Auto-ID Center, and its sister organization EPCGlobal, is the primary resource for RFID tag information.

To understand how RFID is currently being used in the DoD, it is important to have some knowledge of how RFID works, as well as its' way-ahead. This section of the literature review will provide information on current RFID initiatives, and it will discuss the Under Secretary of Defense's recent mandate for RFID tag implementation throughout the DoD.

RFID Tags.

An RFID tag is as small microchip (it can be as small as a grain of sand) attached to a tiny antenna. Active RFID tags, which have been in use for some time, run on a small battery that broadcasts a signal to a receiver. EZPasses, which contain active RFID tags, are currently used to automate payment at toll plazas. When an automobile with an EZPass drives under the RFID reader, the tag broadcasts a signal, and the appropriate toll is deducted from the Pass. Active tags can be read for up to 100 feet (EPCGlobal).

Passive RFID tags, which are the tags currently being mandated for use in civilian industry and by the DOD, do not contain a battery. The passive tag draws power from the RFID reader, which then sends electromagnetic waves that induce a current to the tags' antenna. Passive tags have an average read distance of about ten feet. Semi-passive tags are a cross between active and passive tags, and although they have a battery, they pass and receive data by drawing power from a reader (EPCGlobal).

Some active and semi-passive RFID tags have a read-write capability, which means data can be added to the tag, or can be updated as required. Passive tags are only capable of passing data.

The EPC Code.

As previously mentioned, RFID tags are similar to a barcode, but they provide much more flexibility for reading and writing data. When tracking an item, RFID uses an Electronic Product Code (EPC) to identify the item's manufacturer and product category. EPCs use a string of numbers to separate the item into subsets.

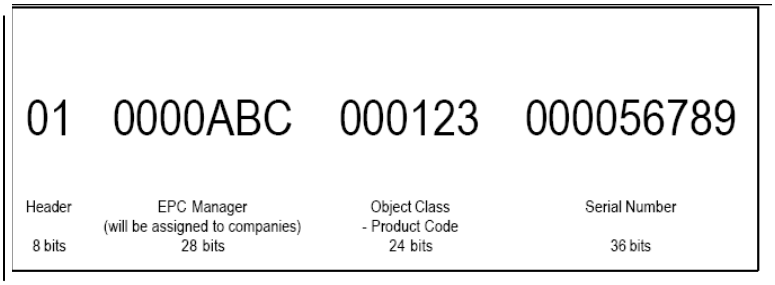


Figure 8. Electronic Product Code (Linster, Liu and Sundhar, 2004)

The EPC in Figure 8 shows a typical data set for a single item.

- The header is the EPC's version number; this builds in flexibility for different lengths of EPCs in the future.
- The EPC Manager identifies the product manufacturer, such as Coca-Cola.
- The third set of data, called Object Class, identifies the exact product type. This is usually the Stock Keeping Unit (SKU), such as "Diet Coke 330ml can, US version."
- The fourth set of data is the item's serial number and is unique to the specific item. In this example, the item would be a particular can of diet coke (EPCGlobal).

RFID System Components.

Data is passed through a system utilizing RFID tagging in the following manner:

An RFID reader, which can be anything from a small, hand-held reader to an archway at a warehouse entrance or exit, is used to collect data from an RFID tag. The antenna on a passive tag generally creates a magnetic field with the antenna on the reader, and the energy produced is used to send radio waves containing digital information (the EPC) from the tag to the reader.

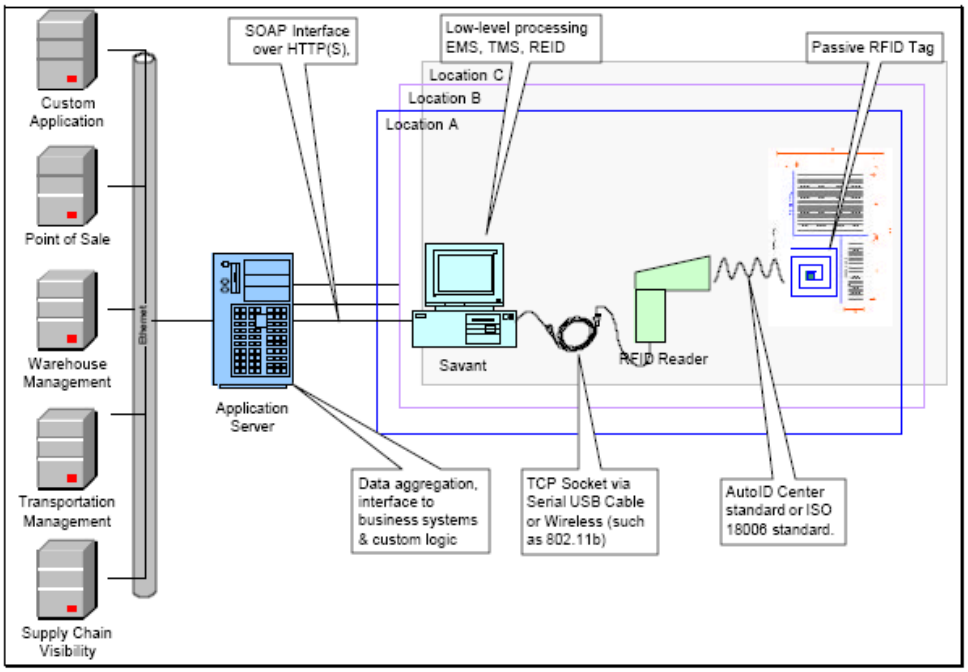


Figure 9. RFID Tagging System (Linster, Liu and Sundhar, 2004)

RFID tags currently operate using different radio frequencies. Ultra high frequency tags are more expensive, but can transfer data faster and have better range (10 to 20 feet). Passive tags, which operate on lower frequencies, use less power and are cheaper. Some readers are only capable of reading one frequency, but readers with the capability to read different frequencies are currently being developed. In addition, RFID tags, when utilized outside the United States, may be forced to operate using different frequencies; readers with the flexibility to read a variety of frequencies are also important due to globalization (EPCGlobal). Table 1. high lights different frequencies currently utilized by RFID.

Research is also being conducted to overcome the difficulty of using RFID to track products containing water or that are packaged in metal containers, since radio waves are obstructed by these substances (Harmon, 2004).

Table 1. RFID Frequencies. (Harmon, 2003)

Frequency	Regulation	Range	Data Speed	Comments
125-150 kHz	Basically unregulated	Å 10 cm	Low	Animal identification and factory data collection systems
13.56 MHz	ISM band, differing power levels and duty cycle	< 1 m	Low to moderate	Popular frequency for I.C. Cards (Smart Cards)
433 MHz	Non-specific Short Range Devices (SRD), Location Systems	1 Ğ 100 m	Moderate	DoD Active
860-960 MHz	ISM band (Increasing use in other regions, differing power levels and duty cycle	2 Ğ 5 m	Moderate to high	EAN.UCC GTAG, MH10.8.4 (RTI), AIAG B-11 (Tires), EPC (18000-6Õ)
2450 MHz	ISM band, differing power levels and duty cycle	1 Ğ 2 m	High	IEEE 802.11b, Bluetooth, CT, AIAG B-11

If a reader, or multiple readers, extracts data simultaneously from two pallets of items, and each item has an individual RFID tag, a reader may have tens or hundreds of chips reflect data simultaneously. The reader sends out a message to each tag, and then separates each piece of EPC data until a unique EPC is identified and read. This deconfliction continues until all tags are read, up to 50 tags per second (EPCGlobal).

Once the EPCs are transmitted from item to reader, the reader relays the codes to a computer which is running a software technology developed by the Auto-ID Center called Savant. Savant is basically the network's "nervous system" (Auto-ID). After Savant receives an EPC from a reader, it sends a query to an Object Name Service (ONS) database, requesting it match the code with the associated product. The ONS server then matches the EPC via a second server which uses Physical Markup Language (PML) and contains extensive information about the product. Data in the PML server is accessible to, and can be augmented by, Savant computers worldwide (Auto-ID).

DOD RFID Mandate.

On 2 October 2003, the Acting Under Secretary of Defense (Acquisition, Technology, and Logistics), Michael W. Wynne, published a memorandum establishing policy for the use of RFID within the DoD. The memorandum directed the following (Wynne, 2003):

- Directed implementation, within our business processes, of the active RFID tags currently used in the DoD operational environment [to meet Combatant Commander Total Asset Visibility] in the following ways:

  Sustainment Cargo: All Layer 4 [Figure 10] Freight Containers and palletized sustainment shipments must have active RFID tags written with content level detail and applied at the point of origin.

  Unit Movement Cargo and Equipment: All Layer 4 Freight Containers and palletized sustainment shipments must have active RFID tags written with content level detail and applied at the point of origin.

  Ammunition Shipments: All Layer 4 Freight Containers and palletized sustainment shipments must have active RFID tags written with content level detail and applied at the point of origin.

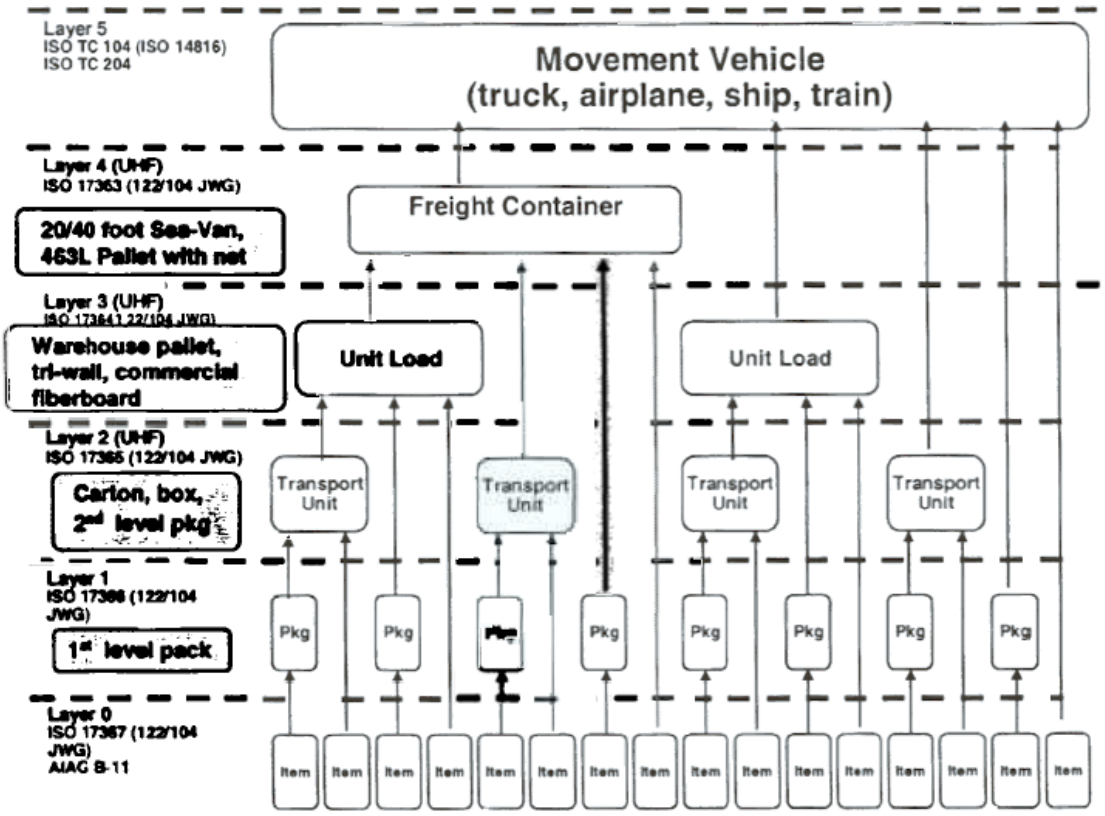
  Prepositioned Material and Supplies: All prepositioned stocks of War Reserve Materials not already issued must have active RFID tags written with content level detail and applied at the point of origin.

  RFID Tags: All active RFID tag files will be written with content level detail in accordance with approved format and sent to the regional ITV servers for further transmission to GTN and other global asset visibility systems as appropriate.

- DOD will be an early adopter of RFID technology that leverages the EPC and compatible RFID tags.
- Suppliers are required to put passive RFID tags on lowest possible piece/case/pallet packaging by January 2005.
- Business rules will be developed no later than May 2004, and a final policy for RFID implementation will be directed in July 2004.

Within the policy memo, Secretary Wynne stated that "We must take advantage of the inherent capabilities of RFID to improve our business functions and facilitate all aspects of the DoD supply chain… Additionally, we will use RFID to improve data quality, item management, asset visibility, and maintenance of materiel" (Wynne, 2003).

Figure 10. Layers of Logistics Units and Applicable Standards (Wynne, 2003)



A second, updated policy letter was published on 20 February 2004, with the following changes and additions:

- DoD Components will continue their maximum effort to immediately implement and expand the use of active RFID tags currently employed in the DoD operational environment.
- DoD Components will plan for a 1 January 2005 implementation of the passive RFID business rules.
- DoD suppliers must put passive RFID tags on the cases and pallets of materiel shipped to the DoD, as well as on the packaging of all items requiring a Unique Identification.
- DoD Components will establish an initial capability to read passive RFID tags and use the data at key sites by January 2005.
- All new solicitations issued after 1 October 2004 for delivery in 2005 will require passive RFID tagging at the case, pallet, and Unique Identification packaging level.
- Provide a final RFID policy and implementation strategy by July 2004.

Secretary Wynne notes in this policy letter that an RFID enabled DoD supply chain "will provide a key enabler for the asset visibility support needed by our warfighters" (Wynne, 2004).

Prior to the DoD directives, General Paul Kern, commander of the Army Material Command, issued an order in January 2003 for all air pallets, containers, and commercial sustainment shipments supporting the war on terrorism to be equipped with RFID tags. The General stated that, "Compliance with RFID tagging policy is absolutely essential.

No other existing system provides the necessary visibility or level of detail. RFID is the only tool that allows CFLCC [Coalition Forces Land Component Command] to identify critical cargo, locate it, and anticipate its arrival. The technology is proven, widespread, and is positively required for CFLCC operations" (Caterinicchia, 2004).

On 17 March 2004, the DoD announced it hired IBM Business Consulting Services under a three-year, $8.4 million contract, to manage and support the new RFID policy. IBM will assist with finalizing the DoD's RFID policy by 30 June, and will help with policy execution. IBM will also be responsible for identifying commercial best practices, developing business rules, educating suppliers, and preparing DoD units for implementation (French, 2004). William Phillips, head of IBM's defense industry consulting business noted that "DoD requirements are similar to industry's at a high level, but as your drill down, DoD's focus is on readiness...it's supply chain is more widely distributed and fluid than most commercial organizations" (Jackson, 2004).

Summary of DoD RFID Policy.

In an effort to improve asset visibility and stay on the leading-edge of technology, the DoD issued directives in October 2003 and February 2004 ordering the mandatory use of active or passive (depending on the shipment type) RFID tags on all containers, palletized sustainment shipments, and cases of material shipped to the DoD. The time-line is extremely aggressive, and a finalized policy and implementation strategy will be published in July 2004.

An important factor to note is the importance the DoD has placed on RFID implementation, with the belief RFID will seamlessly transition to the military. In each memo Secretary Wynne highlighted the importance of RFID implementation to

warfighter asset visibility. He stated "RFID will improve…item management and asset visibility" and "RFID…will provide a key enabler for the asset visibility support to our warfighters." General Kern also noted that "RFID is the only tool that allows CFLCC to identify critical cargo, locate it, and anticipate its arrival…it is positively required for CFLCC operations."

Summary of RFID.

Radio Frequency Identification is an automatic data capture technology that uses radio-frequency waves to transfer data between a reader and an item to identify, categorize, and track information. The implications for usage in both civilian industry and the DoD are incredible, as the instant visibility provides an efficient way to manage inventory and to track items as they travel through the supply chain or logistics network.

But will RFID be able to seamlessly transition to asset tracking within a theater of operations? The goal of this research is to examine if RFID can be effectively utilized to track equipment and supplies by warfighters in-theater. To help answer the question, civilian usage of RFID tagging also needs to be examined, and the next section of the literature review covers current RFID tag usage within civilian industry.

RFID in Civilian Industry

Introduction.

Although RFID is the current logistics and supply chain "buzzword," active RFID tags have been in use for years. What is new about RFID is the leveraging of collected aggregated data to streamline operations, to get a better view of inventory movement, and to respond to situations based on the data provided by the technology (Andrews, 2003).

This section of the literature review will provide background on how RFID tags have been used by industry in the past, and the emerging uses currently being implemented.

Previous/Ongoing RFID Initiatives.

In 1997 the Exxon Mobil Corporation installed the SpeedPass program, which uses RFID to provide quick payment options for customers. To purchase gas, or other items from within the mini-mart, customers wave a small transponder in front of a sensor, which then debits their selected account (Andrews, 2003). Since customers are not required to sign a receipt or enter a pin number, speed and ease of use has made the technology very popular with customers, and over 6 million people have used SpeedPass since its introduction (Booth-Thomas, 2003).

Fast-food retailers, to include the Carl's Jr. hamburger chain, have also implemented RFID sensors for quick and easy payment, and as a result, faster lines at the cashier and drive-through window have decreased wait time (Booth-Thomas, 2003). The EZPass, which is an automated car toll system employed on toll roads throughout the United States, is another current use of active RFID technology (Wolff, 2003).

Other uses include animal tracking and tracing, inventory tracking at clothing retail stores, library book check-out, sports-timing (a runner laces a transponder to his shoe, and his location can be tracked throughout a race), automobile keys, and ski-lift passes (Texas Instruments, 2004).

RFID Way-Ahead within Industry.

In June 2003, Wal-Mart, Inc., announced it will require its top 100 vendors to begin tagging shipping crates and pallets with RFID tags by January 2005, and Wal-Mart will phase-in use of the tags, beginning with pallet and case-level tracking, at three

distribution centers and 150 stores in Texas. Additional roll-outs will continue every quarter, until implementation is complete (Information Week, 2003). Wal-Mart currently has a 99 percent in-stock record, but the missing 1% equals almost $1 billion in lost sales. Consequently, Wal-Mart sees RFID as a potential answer for implementing improvements in inventory tracking and in-stock product maintenance (Quinn, 2004). Wal-Mart will initially focus on using RFID technology to improve inventory management (Vihayan and Brewin, 2003), and then progress, as required, into other uses.

Wal-Mart officials began meeting with 128 companies in November 2003 to map out strategies and benefits of RFID implementation. Although Wal-Mart thinks additional testing is required to perfect RFID tagging, they recognize the potential cost savings and efficiency, and the rationale behind their aggressive move was an effort to bring down the cost of RFID tags and to seize the potential cost savings associated with RFID usage in the supply chain (Quinn, 2004). Wal-Mart's manger of global RFID strategy, Simon Langford, notes, "the primary issue was that the technology was just edging along and it needed a push to achieve a low-cost solution for both tags and readers" (Quinn, 2004). As a result, Wal-Mart decided to mandate the use of RFID tags by their suppliers.

Target issued an RFID mandate in February 2004, requiring "top vendor partners" to apply RFID tags to pallets and cases shipped to "unspecified, select" regional distribution centers beginning in 2005, and all vendors are supposed to comply with the policy by 2006 (Sliwa, 2004). Target has otherwise been quiet about the mandate, and no specifics regarding implementation or usage are being discussed.

Proctor and Gamble has been working closely with the Auto-ID center regarding RFID usage and implementation, and plans to meet Wal-Mart's January 2005 mandate by having RFID tags on every pallet and case. Cost of RFID tags is a major concern with Wal-Mart suppliers (passive tags currently run about $.50 per tag, with the hope of driving the cost down to $.05 per tag), and in an effort to help the industry scale in volume, Proctor and Gamble will purchase their RFID tags from multiple vendors (Kellam, 2003). P&G estimates that 10% to 16% of its items may be out of stock at a given time, and that reducing the number by as little as 10% to 20%, with the use of RFID for inventory tracking, could boost revenue between 1% and 3% (Sliwa, 2003). This equates to nearly $40 million annually.

Gillette committed to purchasing 500 million RFID tags in 2002 (Mello, 2003), prior to Wal-Marts' mandate. Gillette has also been working closely with the Auto-ID Center, as well as with Wal-Mart, to implement RFID as a solution to the lack of transparency in the quantity and nature of their inventory, which results in empty shelves and lost sales (Quinn, 2003).

Unilever is also on the leading edge of RFID implementation within the supply chain, and is focusing on using tags to gain real-time information. Unilever sees many benefits with the usage of RFID, to include tracking products through the supply chain, instantaneously confirming shipped and delivered quantities, predicting product arrival, gaining insight on product shelf-time, and tracking product movement through the supply chain (Ellis and Lambright, 2003).

International Paper Co., who inserted RFID tags within paper rolls in their warehouses, is another company currently using RFID to increase inventory accuracy, decrease inventory levels, eliminate waste, and reduce operating costs (Brandel, 2003).

Mark and Spencer, a gourmet take-out food retailer in England, uses RFID tags to track approximately 3.5 million food trays and dollies (many are reusable), which are supplied to over 200 stores by 300 providers. Employee hands-on time has been reduced by 80%, and the company can now track the trays from supplier to retailer (Booth-Thomas, 2003). Johnson & Johnson also tested RFID technology in several warehouses for inventory tracking, but they have not committed to an implementation time-table.

Many companies are focusing on RFID usage to reduce inventory and distribution expense. "They are looking to shave costs," states Kara Romanow, research director at AMR Research of Boston. "They see RFID as helping them with item management" (Gilligan, 2004).

Minimal literature was available on the usage of RFID for distribution tracking, although transportation giant UPS is working with customers impacted by the Wal-Mart and DoD mandates to determine how to handle the RFID-tagged packages in their distribution centers, and to incorporate RFID tags within its distribution system (Brewin, 2003).

Summary of RFID Usage in Civilian Industry.

Evaluation of the literature showed that civilian companies are only in the early stages of using RFID tags to run their supply distribution networks, and that companies are still working on the initial stages of testing and implementation. In addition, industry focus appears to be on inventory and warehouses management, not distribution and asset

visibility like the DoD. Gilligan notes that, "despite their interrelationships, military and commercial logisticians have different objectives." He states retailers, such as Wal-Mart and Target, see RFID as a way to reduce inventory and the associated expense, whereas the DoD's main objective is to see where an item is at in the supply chain. It is also important to note that many companies, such as J.C. Penny, Sears, and Office Depot, are waiting to see how the Wal-Mart test proceeds in 2005 prior to implementing RFID tags within their organizations.

This literature review provided background on how industry is currently using RFID, and the data collected in this section served two purposes. First, it helped identify civilian companies currently using or implementing RFID tags. To complete the research, some of these companies, (those with global missions and goals that can be compared to the Army's) will be interviewed to gather additional data about what processes they employ, or are employing, to successfully use and implement RFID tags to achieve asset visibility in the warehouse or supply chain. Second, the literature review provided a baseline for questions to be posed during the interviews. The specific methodology and associated questions will be discussed in detail in Chapter 3.

The most important take-away from this portion of the literature review is that civilian industry is in the earliest stages of RFID tag implementation, and that their goal is to use RFID for warehouse and inventory management. The DoD is parallel, if not ahead, of civilian industry on implementation, but is focused on using RFID tags for asset visibility, rather than inventory management.

Having thoroughly reviewed TAV, AIS, and AIT, to include RFID, these processes and technologies need to be linked with the logistics network in OIF. The next

section of the literature review will focus on the Army's logistical network in OIF, and how AIT and RFID-usage were successful, or unsuccessful, during the operation.

OIF Supply Distribution Problems

Introduction.

Operation Iraqi Freedom logistics operations were somewhat similar to those conducted during Desert Storm, with a few major differences. A vast amount of equipment and supplies were already prepositioned within the theater in preparation for another conflict, eliminating the immediate need for shipment of some items. Operating in more of a "just-in-time" environment, U.S. military forces maintained five to seven days worth of supplies during OIF, compared to the 60 days worth of supplies stockpiled for use during Desert Storm. OIF combat operations also lasted longer than the combat phase of Desert Storm, with OIF sustainment operations appearing to continue indefinitely. Finally, forces were spread out farther into Iraq during OIF, and much longer supply lines were required to sustain troops (GAO, 2003).

Despite the advanced preparation and lessons learned from Desert Storm, the military still faced a variety of logistics problems, to include distribution and container issues, material accountability, and lack of asset visibility. This review will focus on the asset visibility issues, as those relate the closest to utilization of AIT and RFID. The literature review includes lessons learned collected by the General Accounting Office (GAO) and the Joint Forces Center for Lessons Learned, as well as lessons learned cited by the Third Infantry Division (Mechanized), Combat Service Support Commanders, the OIF Study Group, and other miscellaneous sources.

Lessons Learned

In April 2003 the GAO deployed a task force to the OIF area of operations to study the DoD's accountability and control over supplies and equipment. Although the final report is not yet complete, a preliminary briefing and report on the Effectiveness of Logistics Activities during OIF was submitted to the Defense Committee of Appropriations, U.S. House of Representatives, in December 2003. The preliminary report highlights several problem areas within logistics, to include lack of asset visibility. Specific logistics issues follow (GAO—04-305R):

- RFID technology was not effectively used to track all material
    - Data entry into asset visibility systems was not consistent or uniform
    - Personnel were not adequately trained in use of asset tracking tools
- Asset visibility and other logistics systems were not fully interoperable. In addition, personnel did not always have access to the systems.
    - Bandwidth and the communications infrastructure could not support asset visibility and other logistics information systems
    - Containers and pallets lacked content descriptions and documentation
    - Receipts were not correctly closed out within asset tracking systems
    - Assets were "pushed" through the theater without units going through a normal requisitions process, limiting asset tracking

The report also highlighted that the in-theater transportation capacity was insufficient to move everything requiring movement.

The Joint Center for Lessons Learned (JCLL) deployed 35 joint staff officers to the AOR, to collect "real-time" data to be applied to lessons learned. The staff spread across the theater, and conducted over 600 interviews with key operations-level leaders and planners. The Center's report outlines 17 major issues, to include theater logistics.

Army Brig Gen Robert W. Cone, Director of the JCLL, presented the findings to the press in October 2003.

Although little was said referencing logistics, the issue about supply line security was addressed. During the interview, a reporter asked about the ambush on the 507th Maintenance Company, and if their line should have been more heavily guarded. BGen Cone remarked "We did have the 507th Maintenance Company. But, in fact, I think what's truly laudable is how quickly we adapted convoy escort procedures and really precluded that from being a major factor again" (Cone, 2003).

The Joint Center for Lessons Learned report, which compiled issues and lessons learned from OIF, highlights a number of logistical issues to include the importance of battlefield distribution from the port of debarkation to the foxhole. Data for this report was compiled by interviewing senior-level managers directly involved in OIF operations, and covers all facets of the war. Although the report highlights many of the major issues previously discussed in greater detail, the specifics are For Official Use Only. In an effort to keep this report's distribution unlimited, I will only summarize the findings mentioned within other reports, as no additional findings relevant to this research were included within the report. Major logistics lessons learned include lack of consistent logistics communication and interoperability, lack of asset visibility, lack of communications bandwidth, lack of training for some logistics systems, "pushing" supplies through the logistics network due to lack of asset visibility and demand, and a long, sometimes unsecured, dynamic distribution chain (JLL, 2004).

During OIF, the Third Infantry Division (Mechanized) (3ID[M]) moved farther and faster than any other ground offensive operation in history (3ID[M] AAR, 2003).

Although successful, “victory was accomplished through brute force logistics,” and logistics challenges led to units operating dangerously low on critical items such as ammunition, fuel, and water.

Major 3ID[M] logistics after action issues, and associated recommendations, are highlighted below (3ID[M] AAR, 2003):

Issue: Inadequate resupply of artillery Class V
Recommendation: Theater must supply adequate transportation assets

Issue: Non-availability of Class IX. For most of OIF, pushes of classes of supply were unpredictable with little or no inventories of what was being pushed until receipt.
Recommendation: Logistics cells should have communication systems allowing units to send and receive data. Some of these lessons learned were also learned in Desert Storm; review of previous after action reports may have helped identify these problems earlier.

Issue: CSS Element Security. CSS elements lacked the confidence and ability to properly secure themselves during convoys.
Recommendation: CSS assets must be integrated in all force on force training events.

Issue: Lack of general transportation assets negatively impacted quantity and consistency of supply support. A shortage in one class of supply over-tasked trucks to move the required supplies, resulting in shortages in other supply classes. These shortages then required a disproportionate amount of transportation to correct.
Recommendation: Acquire additional transportation assets.

Issue: Lack of transportation assets for direct support maintenance…just not enough transportation to move parts around the battlefield.
Recommendation: Acquire additional transportation assets

Issue: Situational awareness of the logistics community.
Recommendation: All logistics nodes should be outfitted with means of voice communication to establish the battlefield and situational awareness required to project requirements, track force movements, and ensure critical logistics information is available to all.

Issue: The division did not have visibility of forward moving supplies.
Recommendation: Improved integration and a more dependable communication system.

Issue: The Movement Tracking system was a success, as it provided situational awareness and enabled the division transportation and movement control offices to communicate with units and provide information.

The 3ID[M] also highlighted the importance of Combat Service Support (CSS) flexibility and having the ability to learn on the move due to the ever-changing environment. To keep supplies moving from the ports to front lines, CSS task forces had to organize additional transportation assets to support resupply and provide extra materials handling equipment (MHE) to assist with processing and moving parts and expeditors at aerial and sea ports to work issues. Additional problems included lack of theater transport for commodity distribution, missing Aerial Port Squadron (APS) equipment, and supply support activity supplemental address problems. CSS personnel were able to find solutions to all these problems, all of which were critical to moving parts and supplies through the system (3ID[M]) AAR, 2003).

The 4ID, who did not arrive in theater until April 03, also cited the importance of logistical convoys and nodes guarding themselves, and noted they were the most common ambush target. They also agreed that the theater level parts distribution "is broken," and recommended bringing plenty of fan belts, tires, generators, control boxes and batteries, as well as spare tires and wheels. Like the 3ID[M], the 4ID[M] noted the lack of transportation assets in theater, and recommended contracting additional assets (4ID[M] AAR, 2003).

The U.S. Army Operation Iraqi Freedom Study Group (OIF SG), commissioned in April 2003 by Army Chief of Staff General Eric K. Shinseki, conducted a thorough review of U.S. Army forces in theater and evaluated their performance during combat operations. The OIF SG found that logistics distribution and management systems did

not adequately support OIF forces, noting that "a decade-long effort to digitize logistics, adopt 'business practices,' and focus on efficiency over effectiveness, is insufficient" for an operational environment. The OIF SG highlighted poor in transit visibility of supplies, stove-piped supply functions, a 700-mile supply line, and complex logistics automation as drivers behind the logistics problems. The study group recommended reviewing logistics doctrine and streamlining automation as two actions (USA OIF SG, 2003).

Col Peter Talleri, Chief of Central Command's logistics transformation and automation division in Qatar, noted that "logistics IT remains under-equipped with communications and lacks interoperability" (Caterinicchia, 16 Jun 2003).

In addition to the ambush issue, Army supply lines had other unique factors to contend with during OIF. BGen Boles, Commander, 3rd Corps Support Command, stated that "brown ice," which forms when rain hits the sand/dust in Iraq, causes the roads to become very slippery, especially for heavy trucks. Blowing dust also causes decreased visibility, and heavy fog in the Tigris and Euphrates River valleys also impacts driving conditions. In addition, the high temperatures in the summer can cause vehicles to reach internal temperatures of 140 or 150 degrees, which causes additional challenges. Finally, Army supply convoys drove from ports in Kuwait, through Iraq, and into Baghdad, a 15.5-hour drive round trip (Boles, 2004). Combine the difficult weather factors, with a 900 kilometer drive and the danger of being ambushed, and the army supply line is a very challenging endeavor.

Summary

A synthesis of the OIF after action reports suggests a common pattern of findings, to include lack of transportation assets; assets being "pushed" through the theater, with no asset tracking capability; limited overall asset visibility; inadequate supply line security; minimal integration between communications systems; and Desert Storm lessons learned not being applied.

These lessons learned will be analyzed in Chapter Four of this research, and will help to guide the comparison between usage of RFID to aid the Army's logistical network during war and RFID usage in industry.

AIT Employment during OIF

This portion of the literature review will outline how the Army employed AIT, and RFID in particular, during OIF, and what problems they encountered with the technology. The review will highlight success stories as well as point out issues and problems. Although problems occurred with the use of AIT and RFID, there were also success stories associated with the technology. It is important to understand the successes to apply to future applications.

As directed by General Franks, Commander of Central Command (CENTCOM), RFID tags were attached to every container and pallet in every shipment entering, transiting, or exiting CENTCOM. In some cases vendors applied the tags, or if not, DoD personnel applied tags at the aerial port, the unit, or the distribution center (Stewart, 2003).

After the cargo arrived at the dock or aerial port in the Continental United States (CONUS), it passed through a mobile or fixed RFID interrogator. The interrogator read

the RFID tag, captured the data, and transmitted it to a management information system. Upon arrival at an aerial port or at the sea port in Kuwait this procedure was reversed, and the cargo passed through another interrogator. The collected data was then used to review inbound shipments, make decisions on allocation, and redirect shipments as required. In addition to RFID, linear and two-dimensional bar-codes were used on military shipping labels to provide both supply and transportation information (Stewart, 2003).

The first two RFID mobile interrogator kits arrived in theater on 31 March 2003, and were installed at Camp Doha. Since that time, over 150 additional interrogators were installed, in addition to hand-held devices, to enhance the Army's asset visibility (Caterinicchia, 1April 2003). When officials from the Defense Logistics Agency tested the technology at a port in Kuwait, they used interrogators to check 179 containers that had been shipped and tagged by commercial vendors. It took the officials 20 minutes to collect the data and have it downloaded to the corresponding Army databases. To accomplish the same task manually would have taken a platoon about two days (Caterinicchia, 1 Apr 2003).

Common-access cards (CACs) were also used during OIF to assist in monitoring troops. The CAC contained important information on the deploying troop, to include completed training, special medical issues, and deployment status. The cards were also used to develop passenger manifests. Contact memory buttons were used to record maintenance activity on Apache helicopters (Stewart, 2003).

Stewart noted that, although the use of AIT increased significantly in OIF, the next step is to implement the technology down to the small unit level, and to expand the

use of RFID beyond just the Army (Stewart, 2003). In addition to implementing AIT and RFID to the tactical level, other problems associated with RFID tags included an inconsistent power supply, reliance on satellite communications due to constantly changing tactical networks, and deciding where to put fixed readers at the forward deployed locations (Caterinicchia, 1 Apr 2003).

The Army's Movement Tracking System (MTS), designed to help logistics personnel communicate and track vehicles as they transited the theater, proved to be a huge success during OIF. Although it proved useful for tracking vehicle locations, it also provided battlespace visibility for commanders. MTS was used to call a MEDEVAC helicopter into Iraq, and another time, commanders saw a unit heading toward a location where the enemy was located, and the convoy was quickly rerouted. The system also provides maps and GPS to the vehicle driver, and enables him to transmit email messages to track and communicate with other vehicles, as well as leadership. The system was initially installed on about 200 vehicles, with plans to install 1,600 more systems (Caterinicchia, 16 June 2003).

Synthesis

DoD personnel from the Assistant Deputy Under Secretary of Defense (Supply Chain Integration) and other military logistics officials attended the GAO OIF Logistics Lessons Learned briefing when it was presented to the House on 6 November 2003. Personnel in attendance generally agreed with the findings, and stated the DoD is already working on solutions (GAO-04-35R, 2003). Solutions being worked include designating the Under Secretary of Defense (Acquisition, Technology, and Logistics) as the Defense Logistics Executive, designating the U.S. Transportation Command as the single process

owner to address in-theater distribution issues, and the DoD policy issued in October 2003 directing the use of RFID tags (GAO-04-35R, 2003).

Although these solutions have been implemented with the emphasis of improving TAV in theater during wartime, will the implementation of RFID-tags solve the problem?

Initial evaluation of the literature shows that RFID technology is not yet mature, but that the DoD is aggressively pursuing its plan, concurrent with industry, to implement the technology. In addition, the DoD is focusing on using RFID tags for distribution, where as industry is focused on warehouse and inventory management, with a goal of reducing costs.

Review of the OIF lessons learned literature highlighted several logistics failures. Although some failures were due to lack of transit visibility, others, such as ambushed supply lines, were unrelated. In addition, differences between logistics distribution in civilian industry and the military during wartime began to emerge.

Summary

Chapter Two laid the groundwork for this research effort by outlining TAV and its subsets AIS and AIT, and then providing background on RFID technology and its emerging use within the DoD and civilian industry. The review also provided information on how AIT was used during Operation Iraqi Freedom by the Army in their supply distribution network, and the problems the Army encountered using these technologies.

III. Methodology

Chapter Overview

This chapter describes the methodology used to conduct the research. It will discuss the research problem and its associated research and investigative questions, describe the research paradigm, and outline the methodologies selected to conduct the study. In addition, the chapter will discuss how civilian companies were selected as interview candidates, and the standardized, open-ended interview questions that were used to conduct the interviews. The chapter will conclude by addressing concepts of empirical grounding, as well as criteria for establishing trust and confidence within the research process and results.

Problem Statement

The purpose of this research was to discover if the business practice of using radio frequency identification (RFID) tags to track equipment and supplies can be effectively used in a war-time environment by the Army's logistics network. The study sought to understand the similarities and differences between how RFID is being used by civilian industry and the Army, and if the civilian practices can apply to a war-time scenario. In addition, the study uncovered some similarities and differences between civilian logistics networks and the Army's logistics network during war. Understanding the similarities and differences associated with these areas were then used to answer the research question.

To address this research problem, the investigative questions, initially outlined in Chapter One, will be answered:

1. How is RFID technology being used by civilian companies to run their supply distribution network?

2. What processes are employed by civilian companies to successfully implement and use RFID tags to help achieve asset visibility in situations similar to the Army?

3. What logistical problems did the Army encounter in their overall supply distribution network in Iraq during the combat phase of OIF?

4. How did the Army's logistics network employ AIT during the combat phase of OIF?

5. What problems did the Army's logistics network encounter with the different AIT during the combat phase of OIF?

6. What similarities and differences exist between the civilian companies' and the Army's implementation and usage of RFID tags?

Research Paradigm

How the Army employed AIT and RFID in its logistics network during the combat phase of OIF, and the associated OIF lessons learned, were presented in Chapter Two. In addition, the literature review described how some civilian companies are currently using or implementing RFID. As a result, the next step in the research was to collect and analyze the data to potentially extract new theory, and to determine what additional information, if any, must be collected to complete the study.

Cresswell defines a qualitative study as one designed to process an understanding of a problem, based on building a complex picture, formed with words, and reporting detailed views of informants (1994). Strauss and Corbin's definition of qualitative research is broader, and defines it as any research that produces findings not arrived at by means of statistical procedures or other quantitative methods (2001). Their definition is

geared toward non-mathematical procedures derived from data collected through observations, interviews, documents, books, and videotapes.

Based on the qualitative nature of the study, a qualitative design was used to conduct the research, analyze the data, and induce theory. Table 2 outlines how this research fit a qualitative approach, and compares the research to characteristics defined by Leedy and Ormrod.

Table 2. Characteristics of a Qualitative Approach to Research

Question	Qualitative	Research Characteristic that Conforms to Approach
What is the purpose of the research?	- Describe and explain - Explore and interpret - Build theory	- To study if RFID tags can be used in a war-time supply network to track equipment
What is the nature of the research process?	- Flexible guidelines - Emergent design - Personal view - Unknown variables	- Data collection leading to additional data collection and interviews - Theories will emerge
What are the methods of data collection?	- Informative, small sample - Observations, interviews	- Data collected using a variety of sources - Interviews
What is the form of reasoning used in the analysis?	- Inductive analysis	- No current theory on this topic exists / goal is to generate new theory through analysis
How are the findings communicated?	- Words - Narratives, individual quotes - Personal voice, literary style	- Data will be displayed in tables - Quotes / narratives will be included in overall written analysis

(Leedy and Ormrod, 2001)

Prior to selecting a specific research paradigm, various qualitative research methods were reviewed. Table 3 below outlines five qualitative methods, each a potential candidate for conducting this study. Of the five methods listed, the grounded theory method fit this study the best, and was used to conduct the research. In addition, content analysis provides some methodology pertinent to this study, and was also incorporated to some extent.

Table 3. Characteristics of Qualitative Research Designs

Design	Purpose	Focus	Methods of Data Collection
Case Study	To understand one person/event in depth	One case/few cases within natural setting	- Observations - Interviews - Appropriate written documents
Ethnography	To understand how behaviors reflect the culture of the group	A specific field site in which people share a common culture	- Participant observation - Interviews - Artifact/document collection
Phenomenological Study	To understand an experience from the participants' point of view	A particular phenomenon as it is typically lived/ perceived by humans	- In-depth interviews - Purposeful sampling
Grounded Theory Study	To derive a theory from data collected in a natural setting	Human actions/ interactions, and how they influence one another	- Interviews - Any other relevant data sources (Observations, historical records, documents, etc.)
Content Analysis	To understand specific characteristics of a body of material	Any verbal, visual, or behavioral form of communication	- Identification/sampling of material to be analyzed (books, newspapers, films, etc.) - Coding of the material

(Leedy and Ormrod, 2001)

Grounded Theory

Strauss and Corbin define grounded theory as a theory that is discovered, developed, and verified through systematic data collection and analysis of data pertaining to a phenomenon (1990). Data collection, analysis, and theory are therefore all interrelated, and the study does not begin with a theory to prove, but with a general area of study from which theory emerges. The research statement identifies the phenomenon to be studied, and also leads toward action and process. Both technical and non-technical literature is important to grounded theory, as both types of literature can be used to discover variables and their relationships, and group them together in different ways (Strauss and Corbin, 1990).

Technical Literature: Reports of research studies, and theoretical or philosophical papers characteristic of professional and disciplinary writing. These can serve as background materials against which one compares findings from actual data gathered in grounded theory studies (Strauss and Corbin, 1990).

Non-technical Literature: Biographies, diaries, documents, manuscripts, records, reports, catalogues and other materials that can be used as primary data or to supplement interviews and filed observations in grounded theory studies (Strauss and Corbin, 1990).

Curry defines grounded theory as a way to provide a framework by which theory can be scientifically and methodically generated by collecting, coding, and analyzing data for a specific objective (1991).

Leedy and Ormrod agree that grounded theory is an approach that uses data to develop theory, and that data collection is field based, flexible, and likely to change over time. They also conclude that interviews, as well as observations, documents, historical records, videotapes, and "anything else of potential relevance to the research question may also be used" (Leedy and Ormrod, 2001).

The primary research method used to conduct this study was grounded theory. The research question was addressed through systematic data collection and analysis, and theory regarding the question emerged as a result of analysis. Although there was some initial concern regarding the amount of data available for study due to the emerging usage of RFID in both the DoD and industry, data was readily available, and multiple companies fit the criteria for being interviewed.

Content Analysis

Although grounded theory was the overall methodology used for this research, content analysis, which is generally used in combination with another methodology, was also used (Leedy and Ormrod, 2001). Leedy and Ormrod define content analysis as a detailed and systematic examination of the contents of a particular body of material for the purpose of identifying patterns, themes, or biases; and analyses is usually conducted on forms of human communication, including books, newspapers, and videotapes (2001). To conduct the study, the researcher defines qualities to be examined, and scrutinizes the material for the characteristics being studied. The data is then often tabulated by frequency to determine whether significant similarities or differences exist relevant to the research question.

This methodology was useful because data was analyzed for similarities and differences to help develop theory, and data was presented in tabular and graphical form to depict the similarities, differences, and frequencies of findings.

Interview Selection

Although some relevant data was collected during the literature review, how RFID technology is being used by civilian companies to run their supply distribution network, and what processes are employed by civilian companies to successfully implement and use RFID tags had to be researched further. As a result, interviews with civilian companies currently using or implementing RFID were conducted.

Company selection was based on several variables. First, current Auto-ID Center Sponsors were identified. Auto-ID Center End-User Sponsors are companies that will buy EPC-related technologies, and each makes a one-time donation of $300,000. Once a

sponsor, the company receives research updates, is eligible to participate in field trials, is able to guide the Center's work, and has access to researchers. Additional benefits include researcher input/field work relating the company's supply chain and expert opinion on RFID technology potentially being implemented by the company (Auto-ID, 2002). By becoming sponsors, companies have shown their commitment to RFID tag implementation. Sponsors include Wal-Mart Inc., Proctor and Gamble, Kimberly-Clark, Gillette, and the Department of Defense.

Global companies with diverse product lines and extensive supply networks were then selected from the Auto-ID Center sponsors, as their logistic networks mirror the Army's the closest. Interview candidates were then selected from companies that met both these criteria, and that appeared frequently in RFID literature.

Based on the above criteria, eight companies were selected as interview candidates. Specific individuals to contact were identified for six of the eight companies, based on speaking at numerous RFID and supply chain conferences and publishing articles. Titles of personnel initially identified to be interviewed included Manager of Global RFID Strategy; Director, Corporate Auto ID/RFID Strategies; Supply Chain Futurist; and Director of Supply Network Innovation.

After initial contact was made, a follow-up e-mail outlining the study's purpose and background, as well as the interview questions, was sent. The e-mail also confirmed an interview time and date, or requested a date the answered interview questions be returned. Although phone interviews were preferred, interviewees were given the option of answering the questions via email. The initial follow-up e-mail also included Privacy Act and confidentiality information.

A standardized, open-ended interview approach was used to conduct the interviews, implying the interview revolved around a few central, standardized questions. In open-ended interviews, the exact wording and sequence of questions are determined in advance, and all interviewees are asked the same questions in the same order. The advantages associated with this method include ease of comparing responses, and it facilitates data organization and analysis. This approaches' major disadvantage is the lack of flexibility available to tailor the interview to specific circumstances (Patton, 1990).

Although the job title of personnel interviewed for this study is included within the research, individuals and firms contacted and who participated in this study will not be identified, per Protocol 04-14-E of the Human Subject Review Board. An Exemption from Human Experimentation Requirements was requested but deemed not required by AFIT/HEH. AFIT/HEH determined the interviewees were not human subjects, but experts providing data on their organization for use within the research.

Five interviews were conducted; three over the phone and two via email. Of the three companies identified but not interviewed, one individual could not be reached, despite over ten attempts; one company scaled back its focus on RFID implementation (this was discovered while reviewing some literature); and no individual could be reached at the third company. Based on data collected during the literature review, the five companies interviewed were the five most important to this study.

Interview Questions

Interview questions were developed to learn how each company is using RFID tags, and the advantages and disadvantage associated with implementation and use.

After interview completion, the responses were combined and then compared to how the Army is using, implementing, and potentially expanding RFID tag usage. Advantages, disadvantages, and noted improvements were also compared. Each question is listed below. (See Appendix A and B for an Interview Worksheet example and a copy of the initial follow-up e-mail format.)

Question 1: *How is your company currently using RFID technology?*

Although all companies identified to be interviewed are using or implementing RFID, each company is in a different phase, or may be using RFID technology for different reasons. This question's goal was to determine whether the company is actively using RFID, or is still in the implementation phase.

Question 2: (Asked as a follow-on to Question 1 if the company was still in implementation/test phase.) *If RFID is not currently in use, how do you plan to initially use it once implementation is complete?*

If the company is still in the implementation phase, it is important to know how RFID will be used once implementation is complete. For example, the company may plan to use RFID tags within supply warehouses only. This data was then compared to current and future RFID tag use within the Army.

Question 3: *How do you plan to expand your use of RFID technology in the future?*

This was an important question because RFID technology is still in the early stages of development for use within the supply chain. A company may initially focus RFID tag usage on warehouse management, but may plan to expand to distribution within the next several years. This data was later compared to the Army's current usage and expansion plans.

Question 4: *What do you consider the top 3 advantages of using/implementing RFID technology in your company? Rank 1-3.*

Once collected and compiled, data collected from this question was compared to the Army's successes with RFID, and considered as potential future areas of implementation for logistics network improvement.

Question 5: *What do you consider the top 3 disadvantages associated with the usage of RFID technology? Rank 1 – 3.*

Like Question 4, these answers were compiled and then compared to the Army's current logistics problems. In addition, they were considered as potential issues.

Question 6: *How have RFID tags improved your supply chain processes?*

This was an important question because it had the potential to provide positive lessons learned from companies that have tackled RFID implementation, and could show how RFID may improve the Army's logistics network.

Question 7: *What problems, if any, have you experienced using RFID in your supply chain process?*

This data was important so a comparison could be made with the Army's logistics network.

Data Sources / Data Analysis

Data from the Literature Review and interviews was analyzed to address the research question and develop theory relevant to the research question and investigative questions. In addition to the analysis, the data was validated and grounded to ensure adequacy of the overall research process. The two methods used to ensure adequacy are outlined below.

Concepts for Empirical Grounding

Strauss and Corbin provide a series of questions which can serve as a means to empirically ground a qualitative study (1990). Although only meant as guidelines, these criteria help verify the grounded theory study. The questions are outlined below in Table 4, and then each category is addressed.

Table 4. Empirical Grounding

	Empirical Grounding for the Study
Criterion #1	Are concepts generated?
Criterion #2	Are the concepts systematically related?
Criterion #3	Are there many conceptual linkages, and are the categories well developed? Do they have conceptual density?
Criterion #4	Is much variation built into the theory?
Criterion #5	Are the broader conditions that affect the phenomenon under study built into its explanation?
Criterion #6	Has the process been taken into account?
Criterion #7	Do theoretical findings seem significant, and to what extent?

Strauss and Corbin, 1990

Criterion # 1: Are concepts generated?

Since no published study on this topic has been accomplished, new concepts were generated as part of this research. The key overall concept was that RFID tags do have the capability to improve the Army's logistics network during war, but only to a certain extent. RFID tags can help improve supply-line asset visibility but will be hindered due to the dynamic nature of the war-time supply line. These topics are discussed in Chapters Four and Five.

Although not a new concept, it was also interesting to learn that the DoD is actually ahead of the civilian sector in the use and implementation of RFID tags, and that industry and the DoD initially plan to use RFID tags for different purposes.

Criterion #2: Are the concepts related?

Due to the limited extent of this research, only a single major concept was generated to answer the research question. Despite this, the other interesting findings—that the DoD is leading the way in RFID tag use, and that the DoD and civilian industry are focusing on different areas of use for the tags—are directly related to the main concept.

Criterion #3: Are there linkages, and are they developed?

The main linkages discovered during this study are highlighted under Criterions 1 and 2, and are discussed in Chapters Four and Five.

Criterion #4: Is variation built into the theory?

Variation is built into the theory based on how quickly RFID technology is developing. Since only a few companies are currently testing the technology, and it has yet to be implemented throughout industry, the technology will continue to develop as use becomes more wide-spread. Due to the potential for future growth, the theory generated by this research could definitely change over the next few years.

Criterion #5: Are the broader conditions built into its explanation?

The broader conditions impacting this research were built into the study by tailoring the investigative questions. The initial investigative question was broad (Overall Army logistics lessons learned in OIF), then narrowed to specifically address problems with AIT in OIF.

Criterion #6: Has the process been taken into account?

The process of employing AIT and RFID tags in the Army's logistics network during the combat phase of OIF was documented in the literature review. In addition, OIF lessons learned were researched and documented. How civilian companies are using RFID tags was also documented, and then these two processes were compared.

Criterion #7: Do findings seems significant, and to what extent?

The idea for this research came about because no study of the Army's logistics network during wartime, and if the use of RFID tags would improve the network, had been accomplished. Due to the continuing development of RFID use by both the DoD and commercial industry, this topic will continue to evolve over time. Regardless, no published study on this topic has been accomplished, and therefore this research is significant.

Criteria for Establishing Trust and Confidence

In addition to Strauss and Corbin's Concepts for Empirical Grounding, Isaac and Michael (1981) adapted specific criteria for establishing trust and confidence in research results. Their criteria are outlined in Table 5, followed by how this research addressed the eight areas. I elected to use this set of criteria because Isaac and Michael combine criteria also recommended by Strauss and Corbin, Leedy and Ormrod, and Miles and Huberman (Strauss and Corbin, 1990; Leedy and Ormrod, 2001; Miles and Huberman, 1994).

Table 5. Criteria for Establishing Trust & Confidence in Research Results

Conventional Research	
Internal Validity	Did variations in the independent variable produce a change in the dependent variable?
External Validity	Can the results of this investigation be generalized to other settings?
Reliability	Are the results consistent, repeatable, and predictable from one study to another?
Objectivity	Are the events under study public and observable so as to allow agreement among investigators?
Naturalistic Research	
Credibility	Will the methodology and its conduct produce finding that are believable and convincing?
Transferability	To what other contextually similar settings can these finding be applied?
Dependability	Within reasonable limits, are the findings consistent with other similar studies?
Confirmability	Are both the process and the product of the data collection and analysis auditable by an outside party?

Isaac and Michael, adapted from Lincoln and Guba, 1997.

Internal Validity.

Internal validity is of most concern when conducting an experiment. Despite this, internal validity can be applied in qualitative research by using multiple sources in the research. The researcher is cognizant of this, and focused on gathering data from multiple sources, to include interviews, reports, articles, and briefings.

External Validity.

This study analyzed the usage of RFID tags in a wartime environment by the Army's logistics network. This research should apply under war-time conditions in similar environments, but if applied to a non-war-time setting or a more special operations-type setting, such as Operation Enduring Freedom, the results would vary due to the different mission of the supply network.

Reliability.

If applied to a similar war-time environment, the research results should yield similar theory. In an effort to increase reliability, the researcher collected data addressing each investigative question from multiple sources, and compared the data to determine similarities and differences.

Objectivity.

All OIF Lessons Learned data was unclassified and readily available. In addition, all data collected on AIT and RFID usage was public, as was some of the data collected on how civilian industry is currently using RFID. Although the industry interviews are not public, the data collected from each interview was annotated on an interview sheet and can be reviewed. Due to the availability of all the data used for this study, other researchers could analyze the same data to reach a conclusion similar to the researchers.

It is important to consider the biases of the researcher, as well as the biases of the personnel interviewed for the study. Although the researcher collected data from multiple sources to increase data reliability, bias could have been a factor when comparing and analyzing the data and forming theories based on the data.

Credibility.

The background data collected for this study enables another researcher to analyze the data and reach potentially similar conclusions. The research also used standardized, open-ended interviews to collect data from industry on the use of RFID tags. Although another researcher could obtain somewhat different results, it is logical to

conclude that asking the same questions to the same interviewee should generate similar answers.

Since the implementation of RFID tagging in industry and the DoD was mandated less than one year ago, usage is still in the implementation stage and little academic research has yet to be published on the topic. As a result, literature reviewed for the study was from periodicals, magazine articles, and government and military reports and briefings, but not from published academic journals. Peer-reviewed, academic literature will certainly become available in the near-term, but little was available for this study.

Transferability.

The research conducted for this study could be transferred to a similar study conducted in a similar environment. Transferable theory generated from this study is outlined in Chapters Four and Five, and additional topics for research are also outlined in Chapter Five.

Dependability.

As mentioned when discussing reliability, data collected was from multiple sources to ensure adequate views and opinions were analyzed and compared. Due to the newness of the research topic, the researcher was unable to locate similar studies. Some literature did discuss opinions similar to the theories generated by this study, and these comparisons are discussed in Chapters Four and Five.

Confirmability.

The data collected for the literature review is public and available. Although specific information regarding the companies interviewed is not public, the interview

questions and responses from this study are available, and can be reviewed for confirmability as required.

Summary

This chapter presented the research methodology as a qualitative design, and outlined using a grounded theory approach, with some content analysis included. It also discussed the research problem and its associated research and investigative questions, and described the research paradigm. The chapter also outlined how civilian companies were selected as interview candidates, and the standardized, open-ended interview questions that were used to conduct interviews. The chapter concluded by addressing the concepts of empirical grounding, and described the criteria used for establishing trust and confidence within the research process.

IV. Analysis and Results

Chapter Overview

This chapter will provide an analysis and results of the research study. It will discuss how RFID is currently being used by civilian organizations, and will answer each of the original investigative questions using data gathered from the literature review and interviews. In addition, it will address additional data gathered during the study pertinent to the research question.

Interview Background

As mentioned in Chapter Three, the five companies interviewed were selected from global organizations currently implementing or testing RFID, and who are Charter Members of the Auto-ID Center. Subject matter experts (SME) interview responses in reference to the first two investigative questions follow, as well as additional data gathered on current and future RFID implementation projects.

Although each of the interviews conducted were with subject matter experts from companies on the leading edge of RFID technology implementation, the interview responses are secondary data based on the interviewee's knowledge. In addition, each interview response was subjective. In an effort to increase reliability, each interviewee was asked the same questions, and validity was increased by interviewing five companies. Although additional interviews would have strengthened the research, any other companies interviewed would have only been in the very early stages of RFID testing and may have had little to contribute.

Investigative Question One

How is RFID technology being used by civilian companies to run their supply distribution network?

Based on the interview responses, none of the companies are currently using RFID technology to run their supply distribution network. One company is tagging cases and pallets of packaged goods to be shipped to select retailers as part of the retailer's pilot test. The other companies are currently conducting field trials or pilot tests, or planning to conduct tests later in 2004.

Although one of the companies is very encouraged by the field tests so far, several others still have concerns about implementation, and are experiencing some technical limitations. In addition, even pilot tests are limited due to the small number of suppliers and/or customers currently testing the technology.

Based on the interviews conducted, RFID technology is still being tested in civilian industry, and has yet to be actively implemented. As of now, no definite implementation date is set by any of the companies, as each of the organizations are waiting for field test results to determine an implementation plan, if warranted. In addition, several companies remain concerned about the overall cost of the technology, and are waiting to see if a positive return on investment is possible. Interface with other systems and overall reader accuracy also remain a concern. As a result, there is currently no direct comparison between how civilian industry is using RFID tags to run their supply distribution networks and how the Army used RFID tags to track supplies during OIF.

Investigative Question Two

What processes are employed by civilian companies to successfully implement RFID tags to help achieve asset visibility in situations similar to the Army?

Although each company interviewed is a Fortune 500 company with a global supply network similar in scope to the Army's, none of the companies are currently implementing RFID with a goal of achieving asset visibility of their distribution network.

Assuming field testing is successful, companies are considering several different areas to focus on regarding initial implementation and usage. Inventory management/ reducing out of stock items and customer service are considered the two most important applications of RFID technology (reference Table 6), and initial focus by the majority of the companies will be to "get the product on the shelf." One company sited applying RFID's capabilities to the distribution network (in addition to warehousing and customer service) as a priority, and another company stated expanding usage (after applying the technology to inventory management) to distribution centers and suppliers.

Reference the actual level of tagging, one company thinks they will begin using tags at the pallet and case level first, and another thinks it may be years (up to 10 or 15) before item-level tagging is possible due to the current cost of tags. Coupled with the current inability to quickly and/or automatically apply tags to products (current applications can tag approximately 60 cases per minute), wide-spread use of item-level tagging may be years away.

Based on data collected from the interviews, companies are still testing RFID tag usage, and the few companies testing the technology are focused on inventory management, not asset visibility. The data collected shows companies initially plan to focus on inventory management, with a potential future focus on distribution.

In addition to the two investigative questions addressed above, each company provided input on their perceived advantages and disadvantages of RFID usage and implementation, as well as its potential to improve the supply chain processes. Their combined responses are outlined and synthesized below.

Advantages

Each subject matter expert was asked to provide what they considered the top three advantages of implementing RFID tags in their company. A summary of the responses is outlined in Table 6. Since the questions were open-ended, some of the interviewees provided very similar advantages, with subtle differences. In these cases, the researcher combined the responses into a single advantage. In addition, several companies provided more than three advantages.

Of the five companies interviewed, four companies identified both customer service and reducing out-of-stock items as advantages of RFID implementation. In addition, three companies listed improving the accuracy/inventory of the supply chain and inventory management as an advantage. Out-of-stock items and inventory management are closely related, and both are subsets of the supply chain. Customer service is directly related to inventory management and retail stock, as customer service levels decrease as out-of-stock items increase. As a result, the research showed increased customer service, resulting from improved retail stockage and overall inventory management, as the greatest advantage of RFID implementation.

Table 6. Advantages of RFID Implementation

Advantage	Comp. A	Comp. B	Comp. C	Comp. D	Comp. E
Improved customer service	X		X	X	X
Reduce out-of-stock items	X	X	X		X
Improving the accuracy / efficiency of the supply chain & inventory management	X			X	X
Reducing loss / error / shrinkage	X		X		
Reduce assets in supply chain due to improved demand signals		X			X
Ensure product gets to the retail store	X				
Reduce raw material / finishing supply inventory w/in mfg facilities		X			
Reduce counterfeit products			X		
No human intervention required to track product location				X	

Although the capability to track assets within the supply chain is directly related to customer service, the data did not mention asset visibility as a potential advantage of RFID implementation. Initial analysis points to a difference in focus between industry and the DoD. Although both industry and the DoD consider improved customer service as an advantage associated with RFID implementation, other perceived advantages, such as improved inventory management versus improved asset visibility, differ.

Disadvantages

Each subject matter expert provided three potential disadvantages (some interpreted this as "complications") associated with RFID implementation. One company

stated it was too early to determine the disadvantages, based on still being in the early stages of testing. A second company also mentioned that additional testing would be required to adequately access the disadvantages associated with the technology. A summary of the responses is listed in Table 7.

Table 7. Disadvantages of RFID Implementation

Disadvantage	Comp. A	Comp. B	Comp. C	Comp. D	Comp. E
Cost		X	X		X
Reliability of the technology		X		X	
Slow development of standards / single vs. multiple standards		X		X	
To early to identify / additional testing required	X		X		
Support / collaboration required by retailers / manufacturers / suppliers to assist in development			X		
Privacy issues				X	
Supplier acceptance					X

Cost was identified three times as the biggest disadvantage associated with RFID implementation; and reliability, and supplier/retailer support and collaboration were both mentioned twice. Aside from cost, no issue was really highlighted as a disadvantage, as only two of the five companies considered reliability and supplier/retailer support as issues. The companies appeared to be more focused and in agreement regarding advantages, versus disadvantages.

Of the disadvantages listed above, reliability, slow development of standards, and support/collaboration are all areas that could impact the Army's distribution network.

Lack of reliability, also identified as a potential problem (discussed later in this section), would negatively impact asset visibility by providing incorrect product identification. In addition, a product could go un-read, and asset visibility and inventory management could suffer.

Although only one civilian company listed privacy issues as a disadvantage associated with RFID tags, privacy issues, or more importantly security issues, are a concern for the Army. As a result, the DoD may require encrypted tags so that changes in radio waves don't provide item identification or location to the enemy (Gilligan, 2003).

Supply Chain Improvement

The sixth interview question asked the subject matter experts how RFID tags improved their supply chain process. Since RFID tag use is still in the testing phase, every subject matter expert responded that it was too early to tell how RFID tags would improve their processes. Despite this, several did provide responses on potential improvements based on their observations from initial test results.

Two SMEs called the technology a "better bar code" and a "21st century bar code," implying RFID tags would enhance the current capabilities provided by bar codes. Two SMEs also saw applications for increased productivity, since more information can be captured automatically or with less labor. In addition, several SMEs noted a potential for improvement in the ability to track products and increase the accuracy of processing and fulfilling orders, as well as improved inventory management.

The potential improvements identified by the SMEs due to RFID implementation could all be improvements in the Army logistics network, also. The DoD already

experienced increased productivity due to RFID tag usage in OIF (to be discussed later in this chapter), and increased product tracking ability is what the DoD hopes to achieve with RFID implementation.

Problems Associated with RFID Implementation

Interview question seven asked the SMEs to provide data on any problems they have experienced in conjunction with RFID implementation. Although most noted they are still in the testing phase and have yet to implement the technology for use in the supply chain, they provided several issues, most of which are similar to the disadvantages highlighted earlier in this chapter.

One company stated there is still a lack of technology, with an emphasis on problems related to RFID tag readers. This SME also mentioned the lack of tag application methods, as large numbers of tags can not be efficiently applied by hand, but no technology exists to quickly apply them automatically. Another company noted that reading products containing liquid or metal continue to be a challenge. This problem was identified by the Auto ID Center several years ago, and continues to be researched. Finally, there are still some issues with interoperability between tags and readers, as well as tag read rates. As for interoperability between tags and readers, the industry SME who identified the problems said the technology works in the tests, "but what about in the real world?" This is also a problem being investigated by the Auto ID Center. Problems with tag read rates varied among the companies, as one company stated they had experienced no read problems, but another company had experienced significant accuracy problems with reading the tags.

The problems being experienced by industry could also be problems experienced by the DoD, in either implementation or supply network usage of RFID tags. Tag application will not be a DoD issue, but issues associated with reading the tags could be. Many DoD supplies contain metal or liquid, and accurate reading rates could suffer. Overall read rates could also be a problem, as could interoperability between tags and readers. If a reader does not have the capability to read a specific a tag, little can be done to correct the problem if in a deployed environment.

Investigative Question Three

What logistical problems did the Army encounter in their overall supply distribution network in Iraq during the combat phase of OIF?

This research gathered data from multiple sources in an effort to compile all major logistics lessons learned from OIF. Each of the reports focused on a different level of war, yet a clear overlap regarding the major logistics problem areas within the theater during OIF emerged. The GAO report had a more strategic and operational focus, the Joint Center for Lessons Learned and Army OIF Study Group were focused more on the operational level of war, the Third Infantry Division (Mechanized) report provided lessons learned from a tactical level, and additional sources focused primarily on the operational level. Table 8 provides a summary of the OIF lessons learned from these reports.

The following issues were highlighted in at least three of the after action reports:

- Poor asset visibility
- Asset visibility and other logistics systems were not fully interoperable

Table 8. OIF Lessons Learned

No.	Lesson Learned	GAO	Third ID (M)	Army OIF Study Group	Joint Center for LLs	Other
1.	Poor asset visibility	X	X	X	X	X
2a.	Asset visibility and other logistics systems were not fully interoperable.	X	X	X	X	X
4.	Bandwidth/communications infrastructure could not support asset visibility and other logistics information systems.	X	X		X	X
5.	Assets were "pushed" through the theater without units going through normal requisitions process, limiting asset tracking.	X	X		X	
6.	In theater transportation system capacity was insufficient to meet transportation/distribution requirements.	X	X		X	
7.	Combat Service Support Element Security		X		X	X
8.	Long and Dynamic Supply Line			X	X	X
1c.	Personnel were not adequately trained in use of asset tracking tools.	X			X	
1a.	RFID was not effectively used in a uniform and consistent manner to track all material within the theater.	X				
1b.	Data entry into asset visibility systems was not consistent or uniform.	X				
2b.	Personnel did not always have access to the systems.	X				
9.	Containers and pallets lacked content descriptions and documentation.	X				
10.	Receipts were not correctly closed out within asset tracking systems.	X				
11.	Dangerous / unpredictable driving conditions					X

- Bandwidth/communications infrastructure could not support asset visibility and other logistics information systems
- Assets were "pushed" through the theater without units going through the normal requisitions process, limiting asset tracking
- In theater transportation system capacity was insufficient to meet transportation/ distribution requirements
- Combat Service Support Element Security
- Long, fast, and dynamic supply lines

The purpose of this research was to discover if the business practice of using RFID tags to track equipment and supplies can be used in a logistics network during wartime. This investigative question contributed to answering the overall question by highlighting problems encountered by the logistics network during OIF. Although RFID does not apply to each of the above lessons-learned, each lesson will be addressed to discuss the potential impact RFID tag implementation could have on the problem.

Poor Asset Visibility

In an attempt to improve asset visibility within the AOR, RFID tags were attached to every container and pallet in every shipment entering, transiting, or exiting CENTCOM. All cargo passed through an RFID interrogator upon entry to the port, and the data was transmitted to an AIS. This system was effective, and RFID tags improved asset visibility at the AOR's ports of entry.

Although asset visibility was in place from CONUS to port, the visibility break-down occurred between port and foxhole. After equipment and supplies left the port, items, even if tagged, were not always visible within the system. For total asset visibility

to exist, all items must be tracked through the entire supply line. Whether RFID tags have the capability to solve or contribute to solving this problem is the major focus of this research.

Lack of Interoperability Between AIS

A problem also cited in Desert Storm, this problem must be solved if RFID is to improve asset visibility. During OIF, data visible in one system was not visible in another. RFID tags may provide the data to improve visibility from item to AIS, but for total asset visibility, the AIS must be able to provide data throughout the supply network to other AIS to ensure JTAV.

Lack of Bandwidth/Limited Communications Infrastructure

Similar to lack of interoperability, this problem must be addressed and solved if RFID tags can be effectively used during war-time to provide JTAV.

Assets "Pushed" Through the Theater

Lack of forward visibility caused rear supply troops to "push" assets. As a result, units did not always know what items were en-route, and multiple orders sometimes resulted. In addition, units received items not requested, while they simultaneously lacked required assets. This issue also compounded the lack of transportation, as vehicles were used to transport items to the wrong unit, only to be rerouted. RFID tagging, enabling tracking from port to foxhole, has the potential to solve this problem.

Insufficient Theater Transportation

This problem is not related to RFID tag implementation and use, but it is an important factor. Although RFID tags may be able to improve asset visibility, other limiting factors to successful movement of supplies may still exist—such as adequate

transportation. This issue can impact many different areas of the supply network, because the same limited assets are required for force projection, sustainment, and redeployment (End-to-End, 2003).

Combat Service Support Element Security

Similar to the insufficient transportation problem, RFID tags are not related to supply line security. Despite this, the problem is also essential to this research because it is unique to war-time or conflict, and can have a huge negative impact on supply line efficiency. Asset visibility may be excellent, but visibility is worthless if supplies can not reach their destination due to a supply line being ambushed.

Long, Fast, and Dynamic Supply Lines

During OIF, the Army supply lines were dynamic, as they kept pace with the Third Infantry and the Marines as they moved forward and north into Iraq. This environment was not conducive to a communications infrastructure, and for asset visibility AIS to work, troops had to set-up the required equipment to ensure proper tracking. Due to the environment, limited time, and/or security issues, setting up the systems was not always possible and as a result, asset visibility suffered. Although RFID tags can improve asset visibility, data must be entered into the system, which at times, may not be possible.

Table 9 summarizes how implementing RFID may impact each of the major OIF lessons learned. Although the "unique to DoD" column is subjective based on the researcher's knowledge, each area was marked based on a global industry supply network. Civilian companies could suffer from lack of transportation assets, but they would/should have the option to purchase, lease, or contract additional vehicles.

Contracting for additional vehicles was the end-answer during OIF, but it was not immediately accomplished. Finally, the in-place communications infrastructure could limit the use of RFID within a civilian business, but they would not have issues like the bandwidth and communications infrastructure issues experienced by the Army during OIF.

In the "Long and Dynamic Supply Line" category, the emphasis is on "dynamic." Many global companies have long supply lines similar to the Army's, but the difference relates to the dynamic nature of the Army's supply line in war. In industry, products are moved to fixed locations, using existing transportation networks. In contrast, the Army's wartime supply line provides supplies to forces continually on the move, and their expected locations may change on short notice, based on changing battlefield objectives. The supply line must then react to these changes, and adjust accordingly. In addition, no fixed routes or roads may exist; they may be improvised as required based on unit location.

Investigative Question Four

How did the Army's logistics network employ AIT during the combat phase of OIF?

As discussed in the literature review, the Army employed AIT in a variety of ways. RFID tags provided asset visibility from the CONUS to port of entry. Initially only two RFID interrogators were available in theater, but over 150 interrogators were eventually employed throughout the AOR.

Linear and two dimensional bar codes were used on all military shipping labels to provide supply and transportation information. CAC cards proved effective to track deploying troops, and contact buttons were used to record aircraft data on Army

Table 9. RFID Applications to OIF Lessons Learned

No.	Lesson Learned	Problem Potentially Solved by RFID?		Unique to DoD logistics network?	
		YES	NO	YES	NO
1.	Poor asset visibility	X			X
2.	Lack of interoperability between AIS		X		X
3.	Bandwidth/communications infrastructure could not support asset visibility and other logistics information systems.		X	X	
4.	Assets were "pushed" through the theater without units going through normal requisitions process, limiting asset tracking.	X			X
5.	In theater transportation system capacity was insufficient to meet transportation/distribution requirements.		X	X	
6.	Combat Service Support Element Security		X	X	
7.	Long and Dynamic Supply Line		X	X	

helicopters. The Movement Tracking System was also an OIF success story, as MTS increased communication and asset tracking throughout the theater.

Investigative Question Five

What problems did the Army's logistics network encounter with the different AIT technologies during the combat phase of OIF?

Although limited data on the overall effectiveness of AIT during OIF in theater was available, data on RFID usage was published by several sources. RFID

implementation was successful from CONUS to port, but RFID tagging was not as successful from the port to the foxhole. RFID required a communications architecture which had to be set-up and taken down, as previously documented, and it was not always possible in a dynamic war-time environment. In addition, the correct placement of the RFID interrogator entry and exit points (if not using hand-held interrogators) and AIS had to be identified prior to set-up. In a dynamic environment, this was not always obvious. Once the infrastructure was in place, security was required, but not always feasible. In some cases during OIF, asset data collected from RFID tags was transmitted via satellite, rather than attempting to set-up the AIS architecture.

System power supply was also an issue, as batteries or a gas generator were required to run the RFID interrogators and AIS. In addition to ensuring the infrastructure had power, maintaining the power source was an issue. Batteries were stolen, and generators did not always have fuel (Ballenger, 2004).

Investigative Question Six

What similarities and differences exist between the civilian companies' and the Army's implementation and usage of RFID tags?

The focus of this research was to answer the question: How can the business practice of using RFID tags to track equipment and supplies be effectively utilized in a war-time environment by the Army's logistics network? To answer this question, current business practices associated with the use of RFID had to researched, and a study was conducted regarding how the Army used RFID during OIF and what problems the Army's supply distribution network experienced during OIF. Having collected this data, similarities and differences regarding RFID use in the private sector and DoD can now be

determined. Compiling the data used to answer the five previous investigative questions will answer this question, and then an overall conclusion can be made to answer the research question.

Table 10 outlines the similarities associated with the use of RFID by civilian industry and the DoD and the Army. Similarities include concerns associated with the new technology, as well as the support required from suppliers to actually implement and use the technology on a day-to-day basis.

Table 10. Similarities

Similarities	
Concerns regarding reliability of technology	The use of RFID tags in the supply chain is a new application of the technology; reliability concerns are shared by both industry and the DoD
Support required by retailers/suppliers	Supplier support is essential to implementation; suppliers must purchase and apply tags to cases, although the DoD applied tags to pallets as required during OIF
Improved productivity	Proven in OIF at sea and aerial ports; highlighted as a potential improvement by industry
Improved customer service	Important aspect of RFID tag implementation for both DoD and industry / improved inventory and asset visibility both lead to improved customer service
Lack of interoperability between systems	Highlighted as a problem in OIF, also mentioned as a potential concern within industry
Concerns regarding tag read rates	Accurate read rates are vital for both civilian and military use
Reduced assets in the supply chain	Based on improved demand visibility, assets in the chain should be reduced through the use of RFID tags. This was an issue during OIF, since supplies were often "pushed" due to lack of visibility.

Differences between the DoD's and industry's use of RFID tags are outlined in Table 11. The first eight differences are based on differences in implementation or use of RFID, and the final ten differences focus on differences in logistics networks, with a focus on lessons learned during OIF. It is important to highlight these differences,

because each made RFID tag implementation difficult during OIF, yet would not be an in issue within civilian industry, or at least not with the same scope or scale.

Table 11. Differences

Differences	Army	Industry	
Field testing RFID tag applications		X	Although not an issue, need to highlight that *industry is field testing the use of RFID tags*
Using RFID tags in the field	X		Again, not an issue, but the DoD proved the technology by tracking pallets and containers from the U.S. to the AOR during OIF
Improve Inventory Management		X	Industry interviews showed primary initial focus will be on using RFID tags to improve inventory management
Reduce out of stock items		X	Considered a major advantage of RFID by industry. Although a useful DoD application, not the current focus
Improve Asset Visibility	X		DoD focus is on using RFID tags to improve asset visibility for the warfighter
Cost		X	Industry is concerned about the cost associated with RFID tag use and implementation / Cost not a major factor for the DoD
Tag Application		X	Tags applied by hand by suppliers / needs to be automated. Tags applied to pallets during OIF, but the requirement was minimal.
Bandwidth/communication infrastructure	X		Bandwidth/communication infrastructure in OIF could not support the requirement to link logistics info systems. Limited asset visibility even with RFID tags
Insufficient transportation for Army supply forces	X		Adequate transportation in-theater not always available during war-time to move supplies
Supply line security	X		Supply line security was a major issue during OIF, and is unique to the DoD's logistics network
Long and Dynamic Supply Lines	X		Army & Marine units continually on the move during war-time/ changing destinations / lack of existing routes roads for goods transport
Set-Up / Take-Down of RFID readers	X		Moving supply lines during war-time require set-up and take-down of readers at each location / Position remains static in industry
Correct Placement of RFID readers	X		With each move during war, correct placement of the RFID readers must be determined prior to set-up / Position remains static in industry
Power Source / Power Source Maintenance	X		RFID reader power must be supplied by generator or battery during war / Batteries subject to pilferage / Power source not an issue in industry
Reader / Power source security	X		Power sources (batteries) subject to pilferage during war / Not an issue with industry, since power is electric
Product Variation	X		Army and civilian companies both have extensive inventory, but *war-time supplies are generally considered more diverse / extensive*
RFID Tag Security	X		Although privacy issues are a concern with industry, DoD must determine how to ensure RFID tags don't provide item identification / troop location to the enemy—*lives are at stake during war*

RFID Tag Use and Implementation

A major difference discovered during the study was the current status of use and implementation of RFID tags. The DoD used RFID tags to successfully track every pallet and container shipped from the CONUS to the AOR during OIF. In addition, the Army used RFID tags to track supplies from the port to the foxhole. Although not as successful as from CONUS to port as previously outlined, tags were applied to all containers and pallets. In contrast, the SME interviews highlighted that a limited number of civilian companies are currently field testing RFID tags, and the technology has yet to be implemented company-wide. Implementation will expand based on the results of the initial field tests, but the results are still unknown.

This finding was interesting because the researcher believed the DoD adopted RFID tags based on a technology proven by industry. The research shows that the DoD is actually ahead of industry on the implementation and use of RFID tags in the supply chain, although the focus for use is somewhat different.

RFID Tag Implementation Focus

Another major difference discovered during the study was how RFID tags are being used, or plan to be used, by the DoD and industry. The DoD's current focus is to use RFID tags to improve asset visibility, both to and from the AOR and within the AOR. As highlighted earlier in this study, RFID usage was mandated by the DoD with the belief that an RFID-enabled supply chain "will provide a key enabler to the asset visibility support needed by our warfighters."

In contrast, industry is focused on using RFID tags to improve inventory management and reduction of out-of-stock items at retail. As highlighted earlier, the

civilian sector is not yet using RFID-tags to improve inventory management, but is testing the technology. Assuming the tests are successful, RFID tags will be applied to improve inventory management.

This finding was also interesting because the researcher assumed the DoD mandated RFID implementation based on current industry use of the technology. On the contrary, not only is the DoD ahead of industry on use, but the focus is different. The DoD used RFID tags to improve asset visibility during OIF, and is expanding implementation with the goal of improved asset visibility within logistics networks. Industry has a different focus, and plans to use RFID tags to improve inventory management and overall shelf stockage.

Cost

Cost was the biggest concern associated with the use of RFID tags within civilian business, but cost was not mentioned as a concern by any DoD source. The difference in the concern is probably related to the difference in focus of use and overall profit motive. Industry plans to use RFID tags to improve inventory management, which may reduce costs for several reasons, to include lost sales due to stock-outs, loss due to pilfierage, and increased revenue due to less required inventory and improved customer service. The DoD does not have a profit motive, and is therefore not as concerned about cost. In addition, the purpose of the DoD's focus on asset visibility is to get supplies to the warfighter/customer.

The Army's War-time Logistics Network

The majority of the differences discovered during the research are related to issues associated with the Army's war-time logistics network and supply line. Each of

these areas was highlighted in the OIF lessons learned or after action reports and relate to complications associated with moving supplies in a war-time environment. Although bandwidth, transportation, security, and dynamic supply lines do not relate directly to the use of RFID, they have a major impact on the logistic network's ability to communicate and move materials, with or without RFID tags. In addition, dynamic supply lines impact RFID tag effectiveness based on the constant requirement to set-up and take down equipment, and to provide a power source. Civilian companies do not have to manage these difficulties in their global supply networks.

An additional difference introduced in this chapter is the wide range of products distributed by the Army during wartime. As an example, Wal-Mart stocks thousands of products, but the DoD has a much more extensive and diverse inventory. Rick Eden, a logistics analyst at Rand noted "I can't build a house with what I buy at Wal-Mart, much less a town. But the Army has to do just that, and then live in the town and run it, when it moves into deployed environments" (Supply Chains, 2003).

Overall, a number of similarities and differences exist regarding how industry and the DoD and Army are implementing and using RFID tags. Both industry and the Army have improved or plan to improve productivity and customer service with RFID tags, and they share similar concerns regarding reliability, supplier support, and system interoperability.

Several major differences regarding implementation were discovered during the research. First, civilian businesses are still only field testing RFID tags, where as the DoD used tags during OIF, and is expanding implementation. In addition, implementation focus is different, since industry plans to use tags primarily for inventory

management, and the DoD is using tags for asset visibility. Other uses linked with successful/unsuccessful implementation were discovered during the study, to include the Army's dynamic supply line and the impact it had on RFID tag usage during OIF.

Summary

This chapter provided an analysis of the data collected for the research study. It discussed how RFID is currently being used by civilian organizations, and answered each of the original investigative questions using data gathered from the literature review and interviews.

V. Conclusions

Chapter Overview

This chapter summarizes the research effort. It will answer the research question and discuss two findings discovered during the study, it will discuss the factors that limited the research, and it will propose topics for future research.

Research Summary

The purpose of this research was to answer the question: how can the business practice of using RFID tags to track equipment and supplies be effectively utilized in a war-time environment by the Army's logistics network? Six investigative questions were developed to address issues associated with this question, and the answer began to develop as the company interviews associated with questions one and two and the overall literature review progressed.

The first two investigative questions focused on how civilian companies are currently using RFID technology to run their supply distribution networks. The majority of this data was collected through interviews with companies identified during the literature review.

Three investigative questions then focused on the Army's logistics network in OIF, how the logistics network used AIT, and what problems the war-time logistics network encountered with AIT. In addition, background information was gathered on RFID and on the Army's AIT systems, since an understanding of the technologies and their applications was imperative to being able to extract data from the literature review

and interviews. An extensive literature review was then conducted to address the investigative questions, as well as provide information on AIT and RFID.

The final investigative question compared the similarities and differences between the civilian companies' and the Army's implementation and usage of RFID tags. The information required to answer this question was based on the data collected to address the five previous questions.

Findings

During the research, two interesting findings were discovered. First, the research revealed a major gap in RFID tag use and implementation between the DoD and civilian business. *The research showed the DoD is ahead of industry on the implementation and use of RFID tags in the supply chain.* The DoD successfully used RFID tags to track every pallet and container shipped from the CONUS to the AOR during OIF, and the Army used RFID tags, to some extent, to track supplies from sea and aerial ports to troops in the field. In contrast, civilian companies are still field testing RFID tags, and the technology has not yet been fully implemented in a supply chain setting.

Second, *the overall focus of how RFID tags are or will be used within the DoD and civilian business is different*. The DoD's current focus is to use RFID tags to improve asset visibility, and this was practiced during OIF. In contrast, industry plans to initially use RFID tags to improve inventory management and to reduce out of stock items. Although asset visibility may become a focus area in the future, initial focus will be inventory management.

Overall Research Conclusion

This research discovered that the business practice of using RFID tags to track equipment and supplies can be utilized in a war-time environment by the Army's logistics network, but there are a variety of factors that will limit implementation and that make a seamless transition from business supply chain to Army logistics network impossible.

The research showed RFID tags successfully tracked pallets and containers from CONUS to ports in the AOR during OIF, and that asset visibility was maintained throughout. Although RFID tags were also applied to containers and pallets moved from ports to troops throughout Iraq through the Army's logistics network, asset visibility was not maintained on all items. Although deploying additional RFID tag readers and providing additional training to supply personnel improved the process (and will continue to improve asset visibility in similar situations in the future), other factors will continue to limit obtaining total asset visibility when using RFID tags in a war-time environment.

The factors listed immediately below are problems inherent to war-time supply lines, and although not directly related to RFID, are major differences between civilian logistics networks and the Army's logistics network during war. These factors must be considered, because they make running military supply lines different from civilian supply lines, and complicate the use of RFID or any other technology.

Factors Unique to the Army's Logistics Network.

Lack of bandwidth / limited communications infrastructure. Although the communication systems may exist to transfer data to provide total asset visibility, limited bandwidth may limit interface between computer systems, and the transfer of data. This

was a complication in OIF, and may continue to be a complication in the future when operating in foreign counties. In addition, logistics troops on the move may not be able to set up the required infrastructure. The lack of bandwidth or a limited communications infrastructure may limit the transfer of data collected from the RFID tags.

Insufficient transportation. Lack of transportation to move supplies to deployed troops throughout Iraq during OIF was an issue, and could be an issue in future conflicts. Although not related directly to RFID or asset visibility, lack of transportation can severely impact the movement of supplies within the AOR.

Supply line security. In a hostile environment, supply lines are at risk. This slows down the movement of goods and may complicate the ability to accomplish other tasks, such as setting up computer equipment and/or RFID readers to track supplies.

Long and dynamic supply lines. During the preparatory and early stages of a conflict, units will be on the move, and supply lines must continually adjust to keep up with the moving target. This may hamper supply personnel's ability to complete other tasks, such as setting up computer equipment and/or RFID readers.

Factors Unique to the Army's War-Time Use of RFID Technologies

Set-up/take-down of RFID readers. Moving supply lines require RFID readers and computer systems to be set-up and taken-down at each new location. This may not always be possible, based on the location, the time spent at the location, the security situation, or the time of day. As a result, RFID readers may not be able to be used, or data up-channeling may not be possible. As a result, asset visibility may suffer.

Correct Placement of RFID Readers. In addition to setting up the RFID readers, correct placement is necessary. There may be issues with the placement, and errors could occur.

Power source/power source security. A power source, usually batteries or a gas generator, must provide power to run the RFID readers and computer systems when supply lines are moving. The power sources may not work, may run out of fuel, or may be stolen (a problem during OIF), making use and transfer of data impossible.

RFID tag security. This area has yet to be addressed, but RFID tags could provide the enemy with troop location or item identification, which could put lives at stake during war.

Research Limitations

The major limitation associated with this research was in conducting the interviews. Company selection was very objective, based on if the company was a member of the Auto-ID Center, if they were a global corporation, and if they were highlighted in the literature as a company aggressively pursuing RFID implementation. Only eight companies met these criteria. In addition, specific individuals responsible for RFID implementation within the company were identified, and these people were contacted to interview.

Interviewing a person at the right level within the company was important, as the individual could not be too far from front line operations, but they needed to be senior enough to speak for the company. The researcher believes the correct companies and personnel were interviewed.

Five company interviews were conducted. Additional interviews may have been beneficial and increased validity, but any additional companies interviewed would have been less advanced in their use and testing of RFID.

The interview questions were open ended, and the responses were recorded and returned to the interviewee for verification. Although the interview questions met the goal of collecting data for the research, other questions may have increased the interviewer's ability to collect data. The open-ended interview questions also left some interpretation up to the interviewee, and had some impact on the data collected. Despite this, the data collected was applicable to the study and met the researcher's goal.

Researcher bias may have been a factor during the actual interviews, and it may have had an impact on the interpretation of the interview data, and the comparison of the interview data to the data collected during the literature review. The researcher was cognizant to the potential for bias during the interviews, and concentrated on asking only the interview questions and providing clarification only when it was requested.

Recommendations for Future Research

A unique aspect of this research was the evolving nature of the topic; RFID tag use is so new to both commercial industry and the DoD, new data applicable to the research effort became available almost daily. The DoD will publish its final policy for RFID implementation in July 2004, and suppliers will begin placing passive RFID tags on the lowest possible piece, case or pallet packaging in January 2005. In addition, Wal-Mart suppliers are also to begin tagging products in January 2005, which means Wal-Mart's use of RFID should broaden, and their suppliers will also be implementing RFID

tag usage to some extent. As a result, additional topics for research will develop as use and implementation of the technology expands.

A future research effort could study the actual progress of the DoD's RFID implementation effort, and if the goals, as outlined in the July 2005 implementation plan, are being met. This effort could also compare the DoD's implementation with on-going implementation in the private sector, reviewing positive and negative aspects of the implementation process and highlighting lessons learned.

An additional research topic regarding RFID tag implementation could focus on RFID tag use at CONUS aerial ports, and compare how implementation and use is being conducted. This could be a bench-mark study, and best-practices could be determined or recommended based on the research. Areas to research at an aerial port could include placement of RFID interrogators, the types of interrogators used, and the actual process of collecting, storing, and using the data. Since this will be a developing process over the next several years, this type of study could have great impact. In addition, AMC could be a viable sponsor.

Although this research focused on RFID tag applications in a war-time logistics network, future research could focus on sustainment in an expeditionary environment, such as Iraq, or use at remote bases, such as Osan Air Base and its co-located operating bases. As RFID-tags become standard on DoD supplies next year, the opportunity to compare how different services are using the technology, leading to benchmarking and best-practice studies, also becomes a possibility.

The DoD is currently focused on using RFID tags to improve asset visibility, where as civilian companies are implementing field tests focused on using RFID tags to

improve inventory management. Once RFID-tag use is implemented by civilian companies (assuming the field tests are successful and tag use is implemented), a study on how companies are using RFID tags for inventory management could be conducted. The study could focus on the potential application of using RFID tags to improve warehouse management at base level, or higher, in the Air Force. This could be a very worthwhile study, and could present new applications for the Air Force to use RFID technology. In addition, other specific areas of the supply chain could be studied. The Defense Logistics Agency, AF/ILS, Air Force Material Command, or any of the other MAJCOMs could be potential sponsors.

Conclusion

This chapter summarized the research effort. It answered the research question, discussed two findings discovered during the study, discussed possible limiting factors associated with the research, and proposed topics for future research.

Appendix A. Initial Contact for Industry Interviews

A two-step process was used to contact companies and schedule interviews. First, initial contact was made via telephone with the individual identified through the literature review as a potential interview subject. This telephone call was followed-up with an e-mail that provided background on the research study and confirmed the date and time of the interview, if it had been scheduled. In two cases a telephone interview was not scheduled, and the individual responded to the interview questions via e-mail.

If an interview was conducted via telephone, the responses were typed and returned to the individual for approval and verification.

A sample of the e-mail initially sent to all individuals interviewed follows. Each e-mail was tailored to whether the interview was to be conducted over the phone at a pre-determined time, or if they were going to answer the questions via e-mail and return.

Thank you in advance for volunteering to assist with this Air Force Institute of Technology (AFIT) research effort!

Reference our conversation on XXX, a summary of the research's purpose and background follows, as well as seven short interview questions.

I will call you at _____ to conduct the interview.

Please respond to the questions and return to me by _____.

Purpose: The purpose of this research is to discover if the business practice of using radio frequency identification (RFID) tags to track equipment and supplies can be effectively used in a war-time environment by the Army's logistics network. The study seeks to understand similarities and differences between how RFID is being used by civilian industry and the Army, and if civilian practices can apply to a war-time scenario. In addition, the study may uncover some similarities and differences between civilian logistics networks and the Army's logistics network during war.

Background: Although combat operations during Operation Iraqi Freedom (OIF) were extremely successful, logistics support problems existed throughout the area of operations (AOR). Identified as "the most challenging operation conducted on the battlefield" in the 3rd Infantry Division's After Action Report (2003), as well as in others, the logistics distribution and management system did not meet all the requirements of the deployed force. Problems included lack of asset visibility, ineffective theater distribution and use of just-in-time practices, supply chain security issues, and failure to apply previous lessons learned. Although implementing business practices such as RFID on the battlefield seems like an easy answer to the lack of asset visibility and ineffective theater distribution, the implementation of civilian business practices may or may not easily transition to a military or combat environment.

Confidentiality of Responses: This information is being collected for research purposes only. The write up and analysis of the interview will be compared to current practices and issues in the Army's logistics network during war-time. Your job title will be included in the research report, and your company will be identified with a letter, such as "A" or "B." No one in your organization will see your responses, and your name and organization will remain confidential.

Question 1: How is your company currently using RFID technology?

Question 2: (Asked as a follow-on to Question 1 if company is still in implementation/test phase.) If RFID is not currently in use, how do you plan to initially use it once implementation is complete?

Question 3: How do you plan to expand your use of RFID technology in the future?

Question 4: What do you consider the top 3 advantages of using/implementing RFID technology in your company? Rank 1 – 3.

Question 5: What do you consider the top 3 disadvantages associated with the usage of RFID technology? Rank 1 – 3.

Question 6: How have RFID tags improved your supply chain processes?

Question 7: (Follow-on to Question 6) What problems, if any, have you experienced using RFID in your supply chain process?

Thank you again for your assistance, and I look forward to speaking to you on

_____.

Thank you again for your assistance, and I look forward to receiving your responses.

Please contact me with questions at any time—

Kris

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PRIVACY ACT STATEMENT

In accordance with AFI 37-132, paragraph 3.2, the information below is provided as required by the Privacy Act of 1974.
Authority: 10 U.S.C. 8012, Secretary of the Air Force; powers and duties; delegation by; implemented by AFI 36-2601, USAF Survey Program.
Purpose: To evaluate the influence of shift work and overtime on the job satisfaction of Air Force members.
Routine Use: To increase understanding of factors affecting retention. No analyses of individual responses will be conducted. Reports summarizing trends in large groups of people may be published.
Disclosure: Participation is VOLUNTARY. No adverse action will be taken against any member who does not participate in this survey or who does not complete any part of this survey.

Appendix B. Interview Questions

Question 1: How is your company currently using RFID technology?

Question 2: (Asked as a follow-on to Question 1 if company is still in implementation/test phase.) If RFID is not currently in use, how do you plan to initially use it once implementation is complete?

Question 3: How do you plan to expand your use of RFID technology in the future?

Question 4: What do you consider the top 3 advantages of using/implementing RFID technology in your company? Rank 1 – 3.

Question 5: What do you consider the top 3 disadvantages associated with the usage of RFID technology? Rank 1 – 3.

Question 6: How have RFID tags improved your supply chain processes? *(*or, How do you think RFID will improve your process?)

Question 7: (Follow-on to Question 6) What problems, if any, have you experienced using/implementing RFID in your supply chain process?

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14. ABSTRACT

Some civilian business practices, such as radio frequency identification (RFID) tags, were used for the first time by the Army in a major conflict during Operation Iraqi Freedom (OIF). RFID tags were attached to every container and pallet in all sustainment shipments entering and exiting the area of operations (AOR). Although RFID tagging was somewhat successful during OIF, the logistics network still suffered significant problems, to include lack of asset visibility and ineffective theater distribution. Implementing business practices on the battlefield seems like an easy answer to these problems, but the implementation of RFID tags may or may not easily transition to a military of combat environment.

The purpose of this research was to discover if the business practice of using RFID tags to track equipment and supplies could be effectively used in a war-time environment by the Army's logistics network. Using grounded theory and content analysis methodologies, this research sought to understand the similarities and differences between how RFID tags are being used by civilian industry and the Army, and if RFID tags can apply to a war-time scenario. Data collection included interviewing industry subject matter experts regarding RFID tag use and implementation, and an extensive analysis of OIF lessons learned. Data was tabulated and compared, and similarities and differences were identified. The research then highlighted how RFID tags could improve asset visibility and theater distribution during war, and the limitations associated with transitioning RFID tags from a civilian supply chain to the Army's war-time logistics network.

15. SUBJECT TERMS
Army Logistics, Operation Enduring Freedom, RFID Tags, Supply Chain

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